**MISSILE DEFENSE AGENCY (MDA)**
**SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)**
**SBIR 07.3 Proposal Submission Instructions**

## INTRODUCTION

The MDA SBIR program is implemented, administrated and managed by the MDA Office of Small Business Programs (OSBP). If you have any questions regarding the administration of the MDA SBIR program please call 703-553-3418 or e-mail: sbirsttr@mda.mil. Additional information on the MDA SBIR Program can be found on the MDA SBIR home page at http://www.winmda.com/. Information regarding the MDA mission and programs can be found at http://www.mda.mil.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (19 July 2007 through 19 Aug 2007), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website by 19 Aug 2007. Please Note: During the pre-release period, you may talk directly with the Topic Authors to ask technical questions about the topics. Their names, phone numbers, and e-mail addresses are listed within each solicitation topic. For reasons of competitive fairness, direct communication between proposers and topic authors is not allowed when DoD begins accepting proposals for each solicitation. However, proposers may still submit written questions about solicitation topics through the SBIR/STTR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing until the solicitation closes. All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other significant information, relevant to the SBIR/STTR topic under which they are proposing.

Proposals not conforming to the terms of this Solicitation will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

Only Government personnel will evaluate proposals. In some circumstances, non-government, technical personnel from **Federally Funded Research and Development Centers (FFRDCs) or support contractors** will provide advisory and assistance services to MDA, providing technical analysis of proposals submitted against MDA topics and applications submitted to the MDA Phase II Transition Program.

**FFRDCs**: Aerospace, Institute for Defense Analyses (IDA), MIT/LL, MITRE

**Support Contractor organizations**: Aegis Technologies, Aerothermo Technology Inc, ANSER, Ball Corp, Booz Allen Hamilton, CC&G, Computer Sciences Inc., CSC, L3, MacAulay Brown Inc., Millennium Engineering and Integration (MEI), Modern Technology Solutions Incorporated (MTSI), Navigation Technology Associates, Paradigm, PRA, SAIC, Schaefer, Simulation Technology, Sparta, Space Dynamics Labs (SDL), Sy Coleman Corp.

Individual support contractors from these organizations will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. These organizations are expressly prohibited from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the source selection process, the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

Pursuant to FAR 9.505-4, the MDA contracts with these support contractors include a clause which essentially requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide technical analysis to the SBIR program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR Program Management Office (PMO).

The MDA PMO will conduct an inventory of all proposals received, in each individual topic area, to ensure no conflict of interest issues exist prior to execution of any advisory and assistance services. If we find that any contractor listed above submits a proposal under an MDA SBIR solicitation, we will verify whether the proposal raises any potential conflicts of interest. MDA anticipates that proposals submitted under a topic area unrelated to the pertinent MDA field activity to which the contractor provides technical support may be allowed if the contracting officer determines that there is no organizational conflict of interest or that any real or apparent conflict of interest is adequately mitigated or avoided.

**PHASE I GUIDELINES**

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept, with a cost not exceeding $100,000. Please refer to section 3.5 of the solicitation for the Phase I Proposal format and requirements.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please assure that your e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, e-mail address(es), or company official after proposal submission.

**PHASE I PROPOSAL SUBMISSION**

**MAXIMUM PAGE LIMIT** FOR MDA IS **20 PAGES**

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

If the offeror proposes to use foreign nationals: Identify the foreign nationals you expect to be involved on this project, country of origin and level of involvement. Please be prepared to provide the following information should your proposal be selected for award: individual's full name (including alias or other spellings of name); date of birth; place of birth; nationality; registration number or visa information; port of entry; type of position and brief description of work to be performed; address where work will be performed; and copy of visa card or permanent resident card. The term "foreign national" is defined in Section 2.15 of this solicitation.

It is mandatory that the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD SBIR Helpdesk at 1-866-724-7457.

This COMPLETE electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal (use of the website's online cost proposal form is MANDATORY for MDA), Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these sections is prepared separately through the website. Only proposals submitted via the Submission website on or before the deadline of 6 a.m (EST) on 19 September 2007 will be processed. ***Please Note:*** The maximum page limit for MDA is twenty (20) pages. Any pages submitted beyond this, will not be evaluated. Your cost proposal, coversheets, and Company Commercialization Report DO NOT count towards your maximum page limit.

**MDA PROPOSAL EVALUATIONS**

MDA will utilize the Phase I Evaluation criteria in section 4.2 of the DoD solicitation, including potential benefit to the Ballistic Missile Defense System (BMDS). MDA will use the Phase II Evaluation criteria in section 4.3 of the DoD solicitation, including potential benefit to BMDS and ability to transition the technology into an identified BMDS. Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror.

**PROPOSAL STATUS AND DEBRIEFINGS**

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by Email regarding proposal selection or non - selection. If your proposal is tentatively selected to receive an MDA award, the PI and CO will receive a single notification. If your proposal is not selected for an MDA award, the PI and CO may receive up to two messages. The first message will notify the small business that the proposal has not been selected for an MDA award and provide information regarding the ability to request a proposal debriefing. The second message will contain debrief status information (if requested), or information regarding the debrief request. **Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced.**

**IMPORTANT:** We anticipate having all the proposals evaluated and our Phase I contract decisions by mid-November 2007. All questions concerning the evaluation and selection process should be directed to the MDA SBIR Program Management Office (PMO).

**MDA SUBMISSION OF FINAL REPORTS**

All final reports will be submitted in accordance with the Contract Data Requirements List (CDRL) of the Contract.

**PHASE II GUIDELINES**

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal. MDA does encourage, but does not require, partnership and outside investment as part of discussions with MDA Sponsors for potential Phase II invitation.

Invitations to submit a Phase II proposal will be made by the MDA SBIR Program Manager (PM). Phase II proposals may be submitted for an amount normally not to exceed $750,000. MDA will consider making Phase II Invitations with a base program of $750K and options*. The base Program and options, together, may total a maximum of $2.5M. If your firm is invited to submit a proposal of an amount greater than $750K, the total amount, for which your firm may submit, will be indicated in the invitation letter. In this circumstance, the base program funds plus the "option" amount will equal the total, possible Phase II contract award value. **You may only propose up to the total cost for which you are invited.**

**Options are additional SBIR funds allocated to a Phase II based upon recommendation by the Research Area Lead in coordination with the Technical Monitor. They are NOT separate and distinct funds exercised during Phase II, but part of the overall Phase II contract award.*

**PHASE II PROPOSAL INVITATION**

An SBIR Topic Sponsor (either an MDA Element, MDA Project Office or MDA Functional Area Office) begins the process for a Phase II Invitation by reviewing the Phase I work of each firm (along with the Contract Technical Monitor) and making a recommendation on which Phase I efforts should continue into Phase II. The MDA Research Area Lead then makes a recommendation based upon the following criteria:

a) Phase I Performance
b) Value to BMDS
   *i.* Potential Phase II Benefits/Capabilities (*Has a BMDS requirement been identified?)*

   *ii.* Phase II Program Benefit (*Does a need exist)*

c) Potential Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?)*
d) Phase II Partnership (*Are there partners identified? What are their commitments?)*

This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I SBIR firm, and the Phase I Technical Monitor.

The MDA SBIR PMO recommends the Phase II Invitation to the MDA SBIR Steering Group. The MDA SBIR Steering Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Selection Official based on the above criteria and the availability of funding. The MDA SBIR Selection Official has the final authority. If approved by the MDA SBIR Selection Official, then a Phase II Invitation is issued.

**PHASE II PROPOSAL SUBMISSION**

**Phase II Proposal Submission is by Invitation only:** *A Phase II proposal can be submitted only by a Phase I awardee and only in response to an invitation by MDA.* Invitations are generally issued at or near the Phase I contract completion, with the Phase II proposals generally due one month later. In accordance with SBA policy, MDA reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards. If you have been invited to submit a Phase II proposal, please see the MDA SBIR website http://www.winmda.com/ for further instructions.

Classified proposals are not accepted under the DoD SBIR Program. Follow Phase II proposal instructions described in Section 3.0 of the program solicitation at www.dodsbir.net/solicitation and specific instructions provided in the Phase II invitation. Each Phase II proposal must contain a Proposal Cover Sheet, technical proposal, cost proposal and a Company Commercialization Report submitted through the DoD Electronic Submission Web Site at www.dodsbir.net/submission **by the deadline specified in the invitation.**

**MDA FASTTRACK DATES AND REQUIREMENTS**

**Introduction:** For more detailed information and guidance regarding the DoD Fast Track Program, please refer to Section 4.5 of the solicitation. The Missile Defense Agency's (MDA's) Phase II Fast Track Program is focused on transition of technology. The Fast Track Program provides matching SBIR funds to eligible firms that attract investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II awards under Fast Track will be for $750K maximum, unless specified by the MDA SBIR Program Manager.

- For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $187,500.)
- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $750,000.)

**Submission:** The complete Fast Track application along with completed transition questions (see note below), must be received by MDA within 120 days from the Phase I award date. The complete Phase II Proposal must be received by MDA within 30 days of receiving approval (see "application assessments for further information). Any Fast Track applications or proposals not meeting this deadline may be declined. All Fast Track applications and required information must have a complete electronic submission. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents is submitted separately through the website. Your proposal must be submitted via the submission site on or before the specified deadlines or your application may be declined.

***Please Note*** – Firms who wish to submit a Fast Track Application to MDA MUST utilize the MDA Fast Track Application Template available at http://www.winmda.com (or by writing sbirsttr@mda.mil). Failure to follow these instructions may result in automatic rejection of your application.

**Application Assessments:** MDA will consider and assess the following in deciding which firms to invite to submit a proposal:

- Value to BMDS
  - Capability/Needs addressed
  - Mission Applicability
- Probability of success and transition into the identified element of the Ballistic Missile Defense System
- Outside investor and advocacy letters
- Availability of funding

Firms are HIGHLY encouraged to engage their technical monitors and also review current BMDS literature including 2006 Strategic Intent of the Missile Defense Agency and Global Ballistic Missile Defense: A Layered Integrated Defense.

Following the assessment, a determination will be made whether or not to invite a firm to submit a Phase II proposal. Notifications will be distributed electronically, via e-mail, to the Company Official listed on the application coversheets. Firms selected during the preliminary assessment process will have thirty (30) days to prepare and submit their Phase II proposal to MDA for final Fast Track consideration and evaluation.

Proposal Evaluation**:** MDA will evaluate invited Phase II proposals in an expedited manner in accordance with the stated criteria (see section 4.3 of the DoD Solicitation), and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria and (2) the project has substantially met its Phase I technical goals. Please Note: Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $30,000. Selection and award of a Fast Track proposal is not mandated and MDA retains the discretion not to select or fund any Fast Track proposal.

**MDA SBIR PHASE II TRANSITION PROGRAM**

**Introduction:** To encourage transition of Small Business Innovation Research (SBIR) projects into Ballistic Missile Defense Systems (BMDS), the Missile Defense Agency's (MDA's) Phase II Transition Program provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. The Phase II Transition Program allows for an existing Phase II SBIR contract to be extended for up to one year per Phase II Transition application, to perform additional research and development. Phase II Transition matching funds will be provided on a one-for-one basis up to a maximum amount of $500,000 of SBIR funds, in accordance with DoD Phase II Enhancement policy. Phase II Transition funding can only be applied to an active DoD Phase II SBIR contract.

The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program must be obligated on the Phase II contract as a modification prior to or concurrent with the MDA SBIR funds. Private sector funds must be from an "outside investor," which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

**Submission:** MDA generally solicits applications twice a year -- around February and June. Please check http://www.winmda.com for program updates and application instructions. All applications must be submitted via DoD Electronic Submission Web Site on or before the MDA specified deadline or may be declined.

**Background:** MDA's technologies are often managed via a Technology Maturation and Transition Program (TMTP) composed of two linked components, technology maturation and technology transition commitment. The TMTP is designed to ensure that all technology development programs in MDA map to a BMDS improvement and, after a period of development and maturity, are transitionable to targeted BMDS end users. End user is defined as the Element, Component or Product Manager to which it is intended to transition the technology. Because of this, it is important that your Phase II be at or approaching a Technology Readiness Level (TRL) of either 5 or 6 at time of application for the MDA Phase II Transition Program.

You may view the Hardware Maturity Checklists for Technology Readiness Levels by clicking **HERE** (http://www.mdatechnology.net/files/trlchecklist.doc). MDA technology developers can use these checklists to determine the level of maturity of their technology. The checklists were created to assess technology in development to verify the level of maturity against uniform, repeatable and objective criteria. This validation helps to ensure that revolutionary technology products enhance the capabilities, reliability and cost effectiveness of the BMDS. **Please Note:** These checklists were developed by MDA as a component of a comprehensive TMTP to help facilitate the relationship between developer and user in the process of transitioning technology-to-component and systems. The TRL checklist information is provided for information purposes only. The application of these criteria can vary by technology characteristics. No official endorsement by MDA of technology maturity is promised or implied for technology assessed by other than TMTP authorities.

Assessments and decisions, on whether or not MDA will fund an application, will be made based upon a review of the following:

- Value to BMDS
  - Capability/Needs addressed
  - Mission Applicability
- Probability of success and transition into the identified BMDS
- Outside investor and advocacy letters
- Availability of funding

Firms are HIGHLY encouraged to engage their technical monitors and also review current BMDS literature including 2006 Strategic Intent of the Missile Defense Agency and Global Ballistic Missile Defense: A Layered Integrated Defense.

**PHASE I PROPOSAL SUBMISSION CHECKLIST:**

*All of the following criteria must be met or your proposal will be REJECTED.*

**____1. The following have been submitted electronically through the DoD submission site by 6 a.m. (EST) 19 September 2007.**

_____ a. DoD Proposal Cover Sheet

_____ b. Technical Proposal (**DOES NOT EXCEED 20 PAGE**S): *Any pages submitted beyond this, will not be evaluated. Your cost proposal, coversheets, and Company Commercialization Report DO NOT count towards your maximum page limit.*

_____ c. DoD Company Commercialization Report (required even if your firm has no prior SBIRs)

_____ d. Cost Proposal **(Online cost proposal form is REQUIRED by MDA)**

**____2. The Phase I proposed cost does not exceed $100,000.**

## MDA SBIR 07.3 Topic Index

### Space Technology

The Space Technology Research area focuses on developing and transitioning technologies to enable or improve the operation of Ballistic Missile Defense System elements in the long-term orbital environment. Current emphasis is on technologies benefiting the Space Tracking and Surveillance System (STSS), but technologies enabling other elements are of longer term interest as well. One of the over-arching requirements for all work in this area is the ability to survive and operate in orbit: this means a tougher natural radiation environment (and potential enhancement by man-made threats) than on earth, the absence of atmosphere, and micro-gravity. Most of the efforts are hardware oriented, but software improvements are also of interest.

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| MDA07-001 | Advanced Sensor Materials for Space |
| MDA07-002 | Advanced Space Power Management & Energy Storage Technologies |
| MDA07-003 | High Performance Rad Hard Analog to Digital Converter Architectures |
| MDA07-004 | Improved Cryocooling Component Technologies |
| MDA07-005 | Legacy Software Conversion Tool |
| MDA07-006 | Low Cost Calibration Targets for MDA System |
| MDA07-007 | Passive Cooling of Laser Diodes for Use on Satellites |
| MDA07-008 | Space Component Miniaturization |

### Interceptor Technology

The Interceptor Technology Research Area will develop technologies that may be needed for current BMD interceptor systems and will enable advanced interceptor concepts.

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| MDA07-009 | Advanced Interceptor Axial Propulsion and Miniature Divert and Attitude Control Systems (DACS) |
| MDA07-010 | Advanced Interceptor Guidance, Navigation and Control (GN&C) Components |
| MDA07-011 | Advanced Synergistic Structures for Interceptor Kill Vehicles |
| MDA07-012 | Interceptor Algorithms |
| MDA07-013 | Interceptor Avionics |
| MDA07-014 | Radiation Hard Interceptor Components Test Methods for Missile Defense |
| MDA07-015 | Interceptor Seekers |

### Modeling and Simulation

The Modeling and Simulation Research Area provides funding for the development of software models to enhance and understand performance issues associated with the BMDS.

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| MDA07-016 | Aerodynamic Drag and Lift Characteristics for Irregularly-Shaped Intercept Fragments |
| MDA07-017 | Develop Consistent First-Principles Earthshine and Skyshine Ultraviolet, Visible, and Infrared Computer Models |
| MDA07-018 | High Fidelity Missile Hardbody Plume Interaction Modeling |
| MDA07-019 | Hypervelocity Intercept Modeling with High-Fidelity, First-Principle, Physics-Based Tools |
| MDA07-020 | Improvements to the BMDS Hit-to-Kill Lethality Predictive Toolset |
| MDA07-021 | Maneuvering Target Phenomenology |

### Manufacturing

The Manufacturing Research Area funds those small businesses that can reduce risk to the MDA by developing technologies, processes or tools that can be used to produce or manufacture systems/subsystems, components, and/or software. Critical metrics that are used in this research area are focused on reducing cost, reducing cycle times, and improving quality and reliability. The typical timeline for transition of the investment to the customer is 3-5 years.

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| MDA07-022 | Advanced Missile Materials and Process Technologies |
| MDA07-023 | Ballistic Missile Defense System Innovative Power Generation and Storage Devices |
| MDA07-024 | Improved Manufacturing Processes for Propulsion Technology |

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| MDA07-025 | Innovative Manufacturing Technologies for Low Cost, High Reliability Electronic Packaging |
| MDA07-026 | Manufacturing Technology Innovations for Advanced Electro Optical Components/Systems for Missile Defense Applications |
| MDA07-027 | Mitigating Lead-Free Issues in Electronic Circuit Board Manufacturing and Repair |
| MDA07-028 | Production Enhancements for Integrated Anti-Tamper Technologies |

**Discrimination**

The Discrimination Research Area funds efforts to develop innovative, discrimination concepts and technologies to enhance and improve BMD sensors (radar, active and passive EO/IR) and sensor/data/information fusion capability to detect, track, discriminate and provide weapon/sensor/decision engagement planning across a spectrum of threat classes and environments facing the BMD System.

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| MDA07-029 | Sensor Data Fusion |
| MDA07-030 | Mitigation of Radar Clutter Using Algorithmic Techniques |
| MDA07-031 | Game Theory In Ballistic Missile Defense (BMD) |
| MDA07-032 | Advanced Passive and Active Sensor Technology for Discrimination |
| MDA07-033 | Forecasting IR Satellite Imagery for Adaptive Sensor Tasking |

**Radar Systems**

The Radar Systems Research Area funds hardware, software and technique related innovations that can reduce the complexity and cost of these systems, while enhancing their tracking performance on multiple objects, sensitivity, bandwidth, and operational reliability. All of the Topics within the Radar Systems Research Area are ITAR Restricted.

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| MDA07-034 | Device Level Thermal Management Solutions for Phased Array Radar |
| MDA07-035 | Innovative Hardware Technologies for Anti-Jam and Electromagnetic Attack Rejection in Ballistic Missile Defense System (BMDS) Radars |
| MDA07-036 | Electrical Interconnect Technologies for MDA Phased Array Radars |
| MDA07-037 | Distributed Aperture Radar Signal Processing Algorithms, Waveforms, and Signal Processing |
| MDA07-038 | RF-Photonic Circuits and Interconnections for Radar Applications |

**Information Assurance**

The Information Assurance (IA) Area funds innovative research and development focused on technologies and tools designed to enhance the security posture of the BMDS. This includes technologies that improve availability, integrity, authentication, confidentiality and non-repudiation.

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| MDA07-039 | Distributed Real-Time Information Assurance Management Technologies |
| MDA07-040 | Configuration Validation Technologies |
| MDA07-041 | Security Policy Reconciliation |
| MDA07-042 | Voice over IP Security |
| MDA07-043 | Ballistic Missile Defense Anti-Tamper Volume Protection |

**Integration**

The Integration Research Area funds hardware and software related innovations that can enhance and protect C2BMC assets applicable to the BMDS.

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| MDA07-044 | Debris Assessment from Spectrally Diverse Sensors and Air Sample to Aid Post-Intercept Weapons Typing |
| MDA07-045 | Automated Battle Management / Planning Aids |
| MDA07-046 | Track Correlation / Sensor Netting |

**Safety/Insensitive Munitions**

The safety and IM research area covers the overall safety of the BMD system and its components. The current focus of this research area is IM and missile propulsion safety including hypergolics and igniters. IM is a DoD requirement derived from U.S. law and addresses the need to minimize munitions' reactions to unplanned stimuli such as fire, bullet and fragment impact. IM is a major thrust area and priority throughout DoD, and, as a result, many new IM technology projects have been initiated. The other related area of research is overall safety improvements to BMD systems. To date, activity in this area has concentrated on new guided missile igniter technology and safer hypergolic propellants for use in attitude control systems. The safety research area is governed by MDA program needs to meet military and NATO safety standards.

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| MDA07-047 | Slow Cook-Off Insensitive Munitions Solutions for Solid Rocket Motors |
| MDA07-048 | Safe Liquid Hypergolic Propulsion Systems |
| MDA07-049 | Insensitive Munitions Solutions for Large Scale Solid Rocket Motors |

**Airborne Component Technology**

The Airborne Component technology funds various research efforts or the Airborne Laser (ABL) program. ABL is the air-based component of the BMDS Boost Phase Defense Segments. It is a highly modified Boeing 747-400 aircraft that will acquire, track, and kill ballistic missiles in their boost phase. Its primary mission is to protect US deployed forces, allies, friends, and areas of vital interest from ballistic missile attack. To ensure ABL meets the mission requirements, the program is interested in technology that improves the design, development, integration, test and sustainment of the ABL weapon system, as well as, enhances performance capabilities.

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| MDA07-050 | High Pressure Singlet Delta Oxygen Generator |
| MDA07-051 | Advanced Hemispherical Reflectance Measurement of Heated Materials |
| MDA07-052 | Fiber Optic Gyro (FOG) Performance Improvement |
| MDA07-053 | Improved Iodine storage, shipping, handling and operations for COIL Lasers |

## MDA SBIR 07.3 Topic Index

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| MDA07-049 | Insensitive Munitions Solutions for Large Scale Solid Rocket Motors |
| MDA07-050 | High Pressure Singlet Delta Oxygen Generator |
| MDA07-051 | Advanced Hemispherical Reflectance Measurement of Heated Materials |
| MDA07-052 | Fiber Optic Gyro (FOG) Performance Improvement |
| MDA07-053 | Improved Iodine storage, shipping, handling and operations for COIL Lasers |

MDA07-001 TITLE: Advanced Sensor Materials for Space

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: DV, SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The overall objective of this effort is to develop innovative sensor materials solutions to improve strategic space sensors. Advanced sensor related areas of interest to the Missile Defense Agency (MDA) include Innovative Materials for both detecting and filtering infrared radiation in a space environment. Specifically sought are new and innovative schemes and technologies that involve modified production processes, improved or new materials, or other innovative options that will increase the detection performance and increase the intrinsic resistance of sensors to both ionizing and nuclear particle radiation damage. Radiation hardness and the ability for the technology to be qualified for space applications are crucial for successful proposals. Proposals submitted must focus on at least one of the following areas: the detector, the antireflective coatings, or bandpass filters. An offeror may submit multiple proposals with unique approaches in one area, or in multiple areas.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in technology developments in support of advanced strategic sensors. MDA requires high performance, high sensitivity and low noise sensors for space based sensing applications. Space based sensors operate in low background photon flux environments where radiation hardness is key to long term mission operation. Sensor bands from the visible through very long wavelength infrared (IR) wavelengths are of interest. Specific technologies of interest include detectors and detector arrays, detector coatings, and optical filters which will: 1. Be capable of operation in a space/nuclear radiation environment; 2. Provide performance sufficient for strategic systems for meeting the requirements of the BMDS; and 3. Offer system performance advantages over current sensor approaches.

The Missile Defense Agency requires new concepts for broadband visible through very long wavelength infrared (VLWIR) detectors and detector arrays with increases of more than 10% in operating temperatures, quantum efficiencies greater than 50%, and improved detectivity for space based applications. Separate approaches to each band of interest, visible (VIS), visible-near (VIS/NIR), short wavelength infrared (SWIR), mid-wavelength infrared (MWIR), long wavelength infrared (LWIR) and very long wavelength infrared (VLWIR) are required. Very long wavelength infrared detectors will be required to operate at wavelengths beyond 20 microns. Development issues include materials design, materials growth and detector processing. Detectors with increased operating temperatures with equivalent or improved detectivity, low noise, and high quantum efficiency will significantly reduce satellite system costs. Key issues to be addressed are innovative detector materials design and device architectures, design, development and demonstration of the interface abruptness between epitaxial layers and repeated control of the individual layers, materials composition, and doping. Additional detector material issues include minimizing background carrier concentration and defect densities. For back illuminated detector architectures, antireflective coatings/treatments have been identified as part of the detector processing. Advances in AR coatings/treatments that operate at cryogenic temperatures, minimize reflections and roll-off and do not deteriorate in a radiation environment are of significant interest. Concepts for all system components must address meeting surviving a 300 kRad(Si) total dose (both proton total dose and ionizing radiation total dose) exposure over the expected mission life.

For infrared applications in military systems it is often necessary to use optical filters which only transmit a given wavelength band while blocking all other wavelengths. Selected substrate and coating materials must transmit (i.e. low loss) specific pass-band wavelengths; LWIR filters with passbands greater than 5μm wide are of particular interest. Ideal filters would obtain transmission greater than 90% and show less than 10% lifetime degradation in the space environment. Improvements on current technology may result from design methodology, deposition monitor and control, or other innovative approaches. Successful filters should simultaneously maximize the throughput in the pass band, minimize the transition from bandpass to blocking, and maximize the blocking in magnitude and spectral extent. They also must display these characteristics at cryogenic temperatures and in a radiation environment.

PHASE I: Identify and investigate materials, unique device designs, novel sensor architectures, and/or production process changes or additions suitable for FPA component fabrication that will result in significant improvement in the performance, operational lifetimes or cost reduction. A deliverable or proof-of-concept design available to the government for additional characterization is highly desirable. Offerors are strongly encouraged to work with system, payload and component contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: In Phase II, the contractor is required to have components available for radiation testing performed on the developed prototype hardware to verify that hardening to protons and ionizing radiation to a total dose of 300 kRads(Si) is established and damage is minimized. Using the resulting materials, designs, architectures, concepts and/or process changes or additions in Phase I, implement, test and verify these changes in prototype fashion to demonstrate the feasibility and efficacy of the focal plane array components. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from, system, payload and/or component contractors.

PHASE III: Either solely, or in partnership with a suitable production foundry, implement, test and verify in full scale the Phase II demonstration item as an economically viable product. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to BMDS systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs. Possible uses for these products include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. Enhancements to imaging quality show significant potential.

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KEYWORDS: infrared detectors; infrared focal plane arrays, radiation hardening, bandpass filters.

MDA07-002 TITLE: Advanced Space Power Management & Energy Storage Technologies

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Electronics, Space Platforms

ACQUISITION PROGRAM: DEP, SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop advanced space power management and storage for MDA satellite applications.

DESCRIPTION: The Spacecraft Electrical Power Subsystem (EPS) performs a critical role for on-orbit operations by providing electrical power to spacecraft subsystems and payloads through a combination of several functions that include energy conversion, storage, management, and distribution. In performance of these functions, the EPS typically consumes more than one third of the spacecraft mass budget. In addition, the components of the EPS often determine the expected lifetime of the spacecraft. The goal of this topic is to develop advanced space power technologies that improve overall EPS performance as measured by EPS system overall efficiency, environmental survivability, and manufacturability. Specifically, improvements are sought in technologies that perform the two EPS functions: energy storage and Power Management and Distribution (PMAD). Power system technologies that perform these functions and are of interest are listed below:

Batteries: Three main interest areas for space-based rechargeable batteries include development of alternate, stable sources of precursor materials used in manufacturing space-grade rechargeable batteries, improving low temperature (below -20C) and radiation exposure (300KRad total dose) survivability and performance of lithium-ion space batteries, and improving the mechanical integrity and handling safety of these batteries. For the precursor aspect of this topic, desired innovations should enable the manufacturing of high purity, consistent cell materials suitable for, or currently used in rechargeable space batteries. Examples include anode, cathode and separator materials for lithium-ion cells, and other materials for nickel hydrogen cells. The second focus area for low temperature operation of space cells encompasses innovations that will allow rechargeable lithium-ion cells to survive short to medium excursions (hours to days) to very cold temperatures without sustaining unacceptable damage or excessive loss of capacity. The final emphasis area includes innovations that increase or alter the mechanical integrity of space lithium-ion cells to help prevent safety incidents resulting from mishandling, accidental short circuits and shocks to personnel who are working with these cells. Proposed battery technologies should complement an overall battery system performance goal to achieve performance levels exceeding the current State-of-the-Art (SOA) in terms of specific energy density (W-hr/kg), volumetric energy density (W-hr/l), cycle life, calendar life, and an operational battery lifetime of 10 years in MEO.

PMAD: Development of PMAD system and component concepts for), radiation hard (300 kRad total dose) applications that reduce mass, volume, operate at high efficiency, and are reliable and producible is desired. While concepts applicable to moderate voltage (28V) systems are of interest, concepts applicable to higher voltage (75-100V) are of particular interest. Increases in PMAD component efficiency and reliability have a ripple effect that can reduce the quantity of batteries and solar cells required by a space system while reducing thermal control issues. Strategies for reducing PMAD mass and increasing efficiency for the high-voltage space environment may involve increased frequency devices, higher bus voltage technologies, distributed power electronics, and increased radiation hardening of existing components. Reliability of components should support a 10 year mission in LEO/MEO.

A single proposal should seek to address only one of the two EPS technologies listed above in relation to the stated MDA satellite applications in sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with their incorporation into DOD systems. Should the proposing firm desire to propose solutions for multiple EPS components, a proposal for each specific concept/technology should be submitted.

PHASE I: Design and develop representative proof of concept hardware for either battery or PMAD technology. This hardware will be tested to characterize performance and to assist in developing a Phase II design strategy. The hardware should be functionally tested in operationally driven modes and analyzed for their path to representative environments. The contractor will identify key technical challenges and establish a plan to address and overcome those challenges. The contractor will also develop a Phase II program plan, including (but not limited to) a development and integration strategy, potential flight demonstration opportunities, program schedule, and estimated costs. Proposing firms are strongly encouraged to work with MDA satellite payload and system contractors to understand the EPS requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PHASE II: Using the lessons learned from fabricating and testing the prototype in Phase I, design and fabricate a prototype concept that can be integrated in an MDA system. The prototype will be tested in accordance with MDA/SS operational and environmental parameters. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from system and payload contractors.

PHASE III: The technologies developed as a result of the Phase II contract(s) will be applicable to many other military and commercial applications that can benefit from the enhanced capabilities, as well as mass and cost savings associated with this technology. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for increased performance of space EPS components is high. Commercial satellite providers are a significant fraction of the space market and are continually looking for ways to reduce system mass, decrease costs, and increase spacecraft reliability and lifetime. Rechargeable batteries are used in commercial aerospace applications for on-board power and innovations developed under this topic are likely to benefit various commercial spacecraft applications.

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KEYWORDS: Electrical Power, Space Power, Power Generation, Power Storage, Power Management & Distribution, Space Based Battery, Power Density, Energy Density, Lithium-Ion, Rechargeable Battery

MDA07-003 TITLE: <u>High Performance Rad Hard Analog to Digital Converter Architectures</u>

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: DV, DEP, SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop (design, fabricate, test) useful, high-performance, radiation-hardened analog-to-digital (ADC) conversion components in one or more of three basic tracts in support of diverse needs of MDA programs.

DESCRIPTION: The signal processing requirements of space based sensor and avionic systems are constantly increasing to meet the threats of the next century. For space based systems, analog-to-digital converter (ADC) requirements are even more severe as the same requirements must be met but in the natural and enhanced radiation environments. The increased performance requirements are becoming especially important as the digital interface moves closer to the sensor/antenna and the ADC performance requirements become a major contributor to space-borne data and signal/sensor processors and mission management specifications. Along with the usual requirements of resolution, power, and speed comes physical size, affordability and reliability. Present DoD requirements for projected systems cannot be met with present COTS ADCs and therefore significant investment in new and novel techniques to meet future requirements is necessary. The needs are eclectic, spanning the simple (i.e., low data-rate, high resolution sampling for guidance, telemetry, health/status) to the more challenging needs of cooled focal plane arrays (i.e., multiple 10-20 million samples/sec (MSPS) channels at 12-14bits). Even more ambitious needs are of interest, such as the ability to acquire even a small number of contiguous samples (i.e. > 32) at very high data rates (> 10GSPS) and resolutions (>10b). Approaching the latter requirement will likely require innovative modular architecture approaches supporting high-resolution and high-speed simultaneously, e.g. through cascadable Sample And Hold (SAH) circuitry.

PHASE 1: Design rad-hard, high performance analog to digital converter architectures that respond to one or more of the following cases: (1) low-data-rate, high-resolution (> 50kSAMPS, > 16b, < 1mW/kS); (2) video-rate (>150 MSPS,>13b,<3mW/MS) with a flexible multi-channel front-end topology having 8-16 channels with aggregate 150MSPS or more; (3) very high rate (>10GSPS,>9b,<1W/GS). In addition to these requirements, it is necessary that the prospective ADC architecture(s) must be capable of meeting performance goals after receiving 300Krad total dose of radiation (ionizing and proton) and suffer minimal performance degradation under the effects of dose rate. In particular, it is desired that the ADC experience no upset in duration in excess of the sampling period. In addition, the ADC design must have an excellent single event effect (SEU,SET) performance, i.e., have the measured ability to achieve less than 10-12 errors/bit-day. Further, there is a high desire to achieve a dose rate recovery to full conversion capability within 10μs after the dose rate event. Model the ADC subcircuits and systems to the extent necessary to verify performance and radiation effects mitigation.

PHASE II: The contractor will produce a working version of the ADC suitable for large scale manufacture. The contractor will work with the Government Program Manager to fully test the component to ensure that the device fully meets the requirements and goals of the objective portion of this RFP. The contractor will work with the Government Program Manager to identify opportunities for insertion of the technology produced by this program into relevant government satellite systems.

PHASE III: The offeror is expected to work with other industry partners and DoD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: Data conversion is a pervasive and ubiquitous need in all system classes. Innovations here will have attractive uses in commercial space, commercial instrumentation, and other industrial systems.

REFERENCES: 1. van de Plassche R. J. CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters (The International Series in Engineering and Computer Science) Kluwer Academic Publishers, 2003.

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KEYWORDS: analog-to-digital, sample-and-hold, data acquisition, ultra-high-speed, radiation-hardened

MDA07-004 TITLE: Improved Cryocooling Component Technologies

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: DV, GM, KI, DEP, SS, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Improve jitter, mass, and/or power performance for electro-optical (EO) space payloads by improving performance of components of the cryocooling system. This performance improvement may consist of: a reduction in the jitter induced by the cooling system; an improvement in heat transfer to, within and or from the cryocooling system; a reduction in weight of or power consumption of the cryocooling system; enabling the transfer of cooling across a gimbal, a flexible joint, and/or to multiple payloads from a single cooler; an ability of the cooling system to rebalance loads vs. temperatures over system life.

DESCRIPTION: Next generation missile midcourse detection infrared sensing technologies and on-board cryogenic cooling needs will require improvements in component level technology that reduce payload jitter, mass, and power budgets through improved thermal management of cooling loads and rejected heat. The issues associated with gimbaled sensor systems are of particular interest. Specific areas of interest are: application of improved heat conduction materials (e.g. composites with anisotropic conductance or conductances greatly above those of pure elements) to cooler or heat transport components; pumped or wicked cryogenic cooling load transfer devices capable of transferring significant (2-10 W) cooling loads across a two axis gimbal, flexible join, or to multiple locations on a spacecraft; cryocooler component improvements, thermal control devices for high density microcircuits, and the control electronics associated with any active devices. All devices must be capable of 10 years operation in a space environment, including 300Krad total dose of radiation (ionizing and proton).

Some notional system within which the improved component will operate must be described. The nominal rejection sink of a usual payload is at 250-325 K and the minimal continuous duty lifetime is 10 years. Two axis gimbals operate across 0-359 degrees in azimuth and 0-90 degrees in elevation. High heat flux microcircuits of interest are the radiation hardened versions of various Field Programmable Gate Arrays (FPGAs) and variants of the Power PC CPU. Proposals concerned with waste heat rejection from or cooling load transfer to refrigerated cryogenic sensors must describe how the thermodynamic system notionally proposed supports 35 K focal plane cooling needs on the order of 2 W and 85 K optics cooling needs on the order of 15 W, or waste heat rejection on the order of 500 W. Multistage refrigeration is therefore an explicit requirement in these payloads. Showing how the component improvement would benefit currently available designs for space EO payload either as efficiency improvements or as reductions in payload budgets must be discussed in the proposal.

Mass improvements for gimbaled payloads are currently assessed relative to the following payload trade budgets:
0.3 kg/W of heat rejection for rejection radiator
0.2 kg/W of power input
30% of refrigerator mass and radiator for on gimbal cooling

Consequently, moving a 100 W refrigerator of 10 kg mass off gimbal would save 0.3 x[10+ (0.3 x 100)] = 12 kg of payload mass. An alternative to save this same 12 kg mass penalty would be to increase cooling efficiency on gimbal so that the power input would be only 45.5 W. It should be obvious from this analysis approach that controlling size (up to an upper linear dimension limit of 2 meters) or component intrinsic mass is not a primary objective of this topic; instead, payload mass savings in excess of 10 kg are the prime mass objective.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts for increased efficiency or reduced mass, jitter, or power input of space EO payloads or their supported spacecraft. This could include demonstration of a process or fundamental physical principle in a format that illustrates how this technology can be further developed and utilized in a space payload simulated in ground testing conditions. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system, payload, and/or refrigeration contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized to flight levels, but should demonstrate the potential of the prototype device to meet actual operational specifications. Demonstration of the potential improvements in efficiency or mass reduction of space cryogenic coolers or space payloads should be included in the effort using commercially-available high-heat-flux parts. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, payload, and/or refrigeration contractors.

PHASE III: Typical MDA military space applications for cryogenic sensing systems relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS). Other potential Phase III opportunities to transfer this technology include the Advanced Infrared Satellite System (AIRSS) and block upgrades to other Ballistic Missile Defense Systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased efficiency and to a lesser extent the expected reduction in mass for cryogenic coolers. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

REFERENCES: 1. Davis, T. M., Tomlinson, B. J., and Ledbetter, J., “Military Space Cryogenic Cooling Requirements for the 21st Century”, Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 1-10.

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KEYWORDS: radiator, cryogenic, Infrared Sensors

MDA07-005 TITLE: Legacy Software Conversion Tool

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Devise an innovative means to reduce the manhours/cost required to modernize Ada applications to run on a new platform (hardware, operating system, and libraries of application programming interfaces) in a new language suitable for real time applications (typically C++, C++.net, Java), and create a system to assist with the modernization.

DESCRIPTION: The Department of Defense has over the years developed a portfolio of many legacy software systems that represent an investment of many years of evolution, typically through spiral development processes. Furthermore, these systems have often proven their reliability in safety-critical situations. However, as hardware, operating systems, and other software, upon which these systems depend are refreshed with new versions, the cost of keeping the legacy systems up-to-date increases. This is particularly acute with Ada code, because the number of Ada developers is shrinking. Therefore there is a growing need to modernize Ada-based systems to more popular programming languages suitable for real-time applications, such as C++, C++.net, Java.
Modernizing a legacy application requires several steps. First, an inventory of the legacy application must be conducted to identify the set of functionality offered by the application that is of value to preserve after modernization, along with all platform dependencies of the application (hardware, (partitioned) operating system, distributed processing, application programming interfaces [APIs] of other software). Second, based on the inventory, an estimate of the work required to modernize the application must be made, to identify which portions of the legacy code are cost-effective to reuse, and which are more cost effective to replace with newly written code. Third, the code that is to be reused must be translated to a new architecture, programming language, operating system, hardware, and APIs, and integrated with any new code written. Fourth, the correctness of the modernized system must be verified.
This topic seeks to advance the state of the art in legacy modernization. The topic seeks a system to support the four steps described above. The solution must support multiple versions of Ada (ANSI/MIL-STD 1815A, ISO-8652:1987, ISO/IEC 8652:1995/Amd 1:2007). The solution should extend or plug into a popular open source development platform for construction of software tools that already contains a rich library of techniques to represent code in abstract syntax trees and to perform refactoring (or reorganization) of source code, such as Eclipse. By extending such a platform, the solution under this effort will benefit from advances in the open source platform in future years, providing maximum functionality to the Government with reduced cost, compared to a stand-alone solution. However the extension itself need not be open source, as is the case with many extensions to Eclipse, to facilitate Phase III commercialization.
The following characteristics are desired. First, Ada code (and any other legacy languages handled by the system) should be reverse engineered into abstract syntax trees for compatibility with Eclipse and other development tools. To address the issue of a declining number of Ada programmers, the system should allow a non-Ada programmer to select a portion of Ada code, and on the fly see the equivalent code in a familiar programming language (e.g., C, C++, or Java). To facilitate reuse, the system should provide a repository to publish reusable functions in the code along with meta-information about the code, in a means that facilitates construction of new software applications through composition. Such a repository should include a machine-readable industry standard form for describing reusable components, such as the Web Services Description Language (WSDL). To assist modernization of human-computer interfaces (HCIs) and integration into new command and control systems, the system should reverse engineer abstract syntax trees of legacy code into an open, cross platform language for representing HCIs, such as the User Interface Markup Language (UIML). The system should also permit annotation of the original software system by developers that analyze the code and perform modernization. To assist with platform dependencies, the system should provide a representation to enumerate dependencies and describe mappings to a new platform.

PHASE I: Develop an innovative methodology (not a wrapper technology) and conceptual design of a tool that performs the four steps listed above. The offeror must demonstrate the technical feasibility and economic merit of the proposed solution. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system and/or payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Refine the methodology of Phase I, and implement and demonstrate a prototype of the innovative concept by applying technologies to the problem of modernizing key sections of a large, complex software system currently implemented in Ada, possibly in combination with other languages. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system and/or payload contractors.

PHASE III: Mature the prototype, extend to additional programming languages and platforms, apply to a target DoD system, and develop a commercial offering. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: The innovation requested in the topic will result in manpower and cost savings in the modernization of safety critical systems. Such an innovation has direct application to many branches of the Federal government, transportation, aerospace, and other industries that increasingly utilize large software systems for critical functions that evolve over time. As a result, the commercial potential for this topic is extremely high. In addition, numerous military systems would benefit.

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2. ISO/IEC 8652: Information technology — Programming languages — Ada, http://en.wikipedia.org/wiki/ISO_8652

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4. W3C, Web Services Definition Language (WSDL), http://www.w3.org/TR/wsdl

KEYWORDS: Ada, Legacy reuse, Software estimation, Software reengineering, reverse engineering, HCI

MDA07-006 TITLE: Low Cost Calibration Test Objects for MDA Systems

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: DV, SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop low cost electro-optical calibration test objects compatible with sounding rockets or micro satellites.

DESCRIPTION: The Missile Defense Agency (MDA) has a requirement for low cost test and calibration targets for a variety of electro optical sensors. Previous solicitations have focused on targets for MDA ground based radar systems. The emphasis in this solicitation is on low cost optical calibration and test objects for either the STSS or ABL systems. These systems employ a variety of passive optical sensor and in the case of the ABL active optical sensors in their tracking systems. Target objects that have well understood radar properties to support range operations and truth measurements are a plus.

The critical requirement in this solicitation is to produce test objects with well characterized optical cross sections and irradiance. For many missile tracking systems, testing often include a complex and expensive target vehicle. Because of the high cost of these targets, test campaigns become milestones rather than experiments that provide useful data to improve the performance of the system. The result is an emphasis on success rather than true experimentation and testing. Complex system tests will always be required for operational system to verify their performance; however, low cost target vehicles are needed to enhance technology develop and to increase the number of experiments that can be conducted before full scale testing is initiated. The development of low cost test articles will enhance the development and testing of advanced detection and tracking technologies for missile defense programs.

Small sounding rocket missions provide the means for low cost experimentation. The key aspects missing for these systems to be utilized are low cost test targets (less than $250K) and an ejection or dispersion system. Since these missions will be flown on sounding rockets, mass is a premium, and the total system mass must be less than 100 kg. In addition, the size of the system should be scalable from 14" to 22" in diameter and 12" to 36" in length to maximize the number of vehicles that can be used. As for the targets, they must provide well quantified and reproducible properties for accurate electro optical characterization, calibration, and testing.. The test objects should have optical cross sections on the order of one meter in the visible and near IR spectrums. The ability to resolve closely space objects is of significant interest so the ability to accurately deploy at least two objects within one half meter of each other is desired.

Since low-cost space targets can provide daily, on-orbit, calibration and test opportunities for missile detection assets under development and in deployment target concepts that can be evolved into micro satellite payloads are of interest to the MDA. Such payloads should be compatible with a reasonable low-cost micro satellite (nominally 50-kg, 40-W OAP). These test objects provide an opportunity to test and calibrate IR sensors on a variety of land, sea, air and space platforms. The radiance required from such objects is on the order of 1-25 W/m2 in the Mid- though Long-wave IR bands.

PHASE I: Develop conceptual designs of the hardware based on preliminary analysis. Perform sufficient hardware development and testing to verify requirements can be met. Phase I should also result in a clear technology development plan, schedule, budget, requirements documentation, and CONOPs for the development to flight hardware. Offerors are strongly encouraged to work with system and payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Demonstrate the full design developed in Phase I. Tasks shall include, but are not limited to, a detailed demonstration of key technical parameters that can be accomplished and a detailed performance analysis of the technology. The Phase II work will ideally produce flight worthy hardware that can be integrated and launched on a government acquired sounding rocket to demonstrate the viability of the concept. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DoD offices to modify and improve the design of the Phase II proof of concept prototypes to meet individual system applications. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: The successful development and demonstration of this technology is expected to result in continued use by MDA and other DOD organization. As these test objects mature they will be of interest to the international laser ranging community and eventually to Astronomers as calibration sources for telescope systems. There is a large and growing market for testing electro optical based detection systems within the defense industry.

REFERENCES: 1. MDA Link Fact Sheet: Space Tracking and Surveillance System, http://www.mda.mil/mdalink/pdf/stss06.pdf

2. MDA Link Fact Sheet: Airborne Laser http://www.mda.mil/mdalink/pdf/laser.pdf

3. Public Law 106-65, Oct 5, 1999, Congressional Direction, Appendix G, Space Technology Applications, Space Test Program

KEYWORDS: low cost target, electro optical, sensor, calibration, characterization, sounding rocket, ejection system

MDA07-007 TITLE: Passive Cooling of Laser Diodes for Use on Satellites

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms

ACQUISITION PROGRAM: DV, DEP,SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop innovative concepts and thermal control architectures for cooling laser diodes and other high power components for satellite systems.

DESCRIPTION: With ever-growing demand for secure communication bandwidth, laser communication or lasercom is of increasing interest to MDA. For these systems, laser diodes in the high power laser transmitters present significant challenges for thermal management, especially for satellite systems where many terrestrial cooling techniques are not feasible or are impractical. The primary problem for laser diode cooling is dissipating the intense heat that is generated at the junctions. Heat flux as high as 700W/cm2 must be continuously dissipated across the laser diode array. In addition, the heat sink temperature must be maintained below 30°C to ensure proper operation. The second problem that must be addressed for laser diode cooling is temperature stability, which includes both stability across the array and stability over time. Increasing the temperature stability of the system improves the reliability and lifetime of the components, which are important for satellites.

There are a number of laser diode cooling methods being investigated for Earth-based applications. However, many of these concepts are incompatible with or impractical for space applications. For example, micro-channel pumped fluid loops and spray cooling are viable techniques for terrestrial applications. However for space use, they present a number of challenges including leakage, pump reliability, mass, and power consumption. For satellite systems, passive cooling is ideal because it eliminates the problems associated with active systems while also reducing system complexity.

For the reasons stated above, the MDA is seeking innovative solutions for passive cooling of high power density laser diode arrays. These concepts must be able to continuously cool a 60W laser diode array that is generating heat at 700W/cm2. The concepts must also maintain a heat sink temperature of less than 30°C while maximizing the thermal stability of the array to ensure reliable, long duration use. In addition, mass and power consumption are obviously important for spacecraft technologies. The threshold laser diode cooling system mass goal is 25kg, and the objective is 10kg. As for power consumption, up to 10W can be provided; however, purely passive solutions requiring no input power are preferred. Finally, all proposed solutions must be compatible with the space environment and conform to space qualification requirements including high vacuum, microgravity, radiation, atomic oxygen, low outgassing, and high launch loads.

For proposed concepts, the entire system solution must be clearly detailed including acquiring heat at the diode and transferring it to the primary sink for rejection.

PHASE I: Develop conceptual designs of the hardware based on preliminary analysis. Perform sufficient hardware development and testing to verify requirements can be met. Proof of concept experiments shall be conducted to indicate the practicality of the design in meeting requirements and objectives. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system, payload, and/or laser contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Demonstrate the technology identified in Phase I. Tasks shall include, but are not limited to, a detailed demonstration of key technical parameters that can be accomplished and a detailed performance analysis of the technology. A subscale demo is acceptable, but a full-scale demo is encouraged. Also, model validation testing, a detailed evaluation report, and recommendations are required. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, payload, and/or laser contractors

PHASE III: The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS). Other potential Phase III opportunities include block upgrades to other Ballistic Missile Defense Systems and DoD/Commercial communication satellites.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Passive, high power cooling technologies have many applications in addition to laser diode cooling including RF components and processors and are applicable to a wide range of systems including spacecraft, aircraft, and ground vehicles. Many future military systems are expected to have severe cooling problems. Potential commercial applications for passive high power cooling technologies include commercial versions of the military applications. In addition, there are applications for high power electronics, microelectronics, and PC processors.

REFERENCES: 1. Gilmore, David G., Spacecraft Thermal Control Handbook Volume I: Fundamental Technologies, 2nd Ed, The Aerospace Press, El Segundo, CA, 2002.

2. Sloan, Joel L., Design and Packaging of Electronic Equipment, Van Norstrand Reinhold Company, New York, 1985.

3. Steinberg, Dave S., Cooling Techniques for Electronic Equipment, 2nd Ed., John Wiley & Sons, Inc., New York, 1991.

KEYWORDS: Laser diode cooling, thermal management, high heat flux, passive cooling, high power, thermal stability, satellite, space technology

MDA07-008 TITLE: Space Component Miniaturization

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and test miniaturized, lightweight, space qualified components. Special emphasis for this topic shall be in two areas. The first area of emphasis is micro-electro-mechanical systems (MEMS) gyros for use in laser communication architectures, optical system line of sight determination, and optical inertial reference units for long-range acquisition, tracking and pointing applications. The second area of interest is in the development of lightweight, high efficiency motors for use in optical gimbal systems. Offerors may propose other highly innovative miniaturization efforts.

DESCRIPTION: Proposed MDA systems, such as the Space Tracking and Surveillance System (STSS), require extremely high-resolution Line of Sight (LOS) stabilization and inertial pointing knowledge. To achieve these mission objectives, STSS is very interested in the development of high performance, space qualified MEMS gyros to provide absolute inertial line of sight knowledge and the necessary low frequency sensor information to support control system LOS stabilization for the pointing and tracking system. Another aspect of this requirement is high precision, high efficiency, light weight gimbal motors to position and track with the optical telescope.

The performance goals for space qualified MEMS gyros are presented below are specifically tailored to support future space surveillance missions.

Performance Goals:

| | Near-term Goal | Far-term Goal |
|---|---|---|
| Bias Drift Stability, 1 ó, 8 hr | < 0.01 deg/hr | < 0.005 deg/hr |
| g-sensitive bias drift | < 0.005 deg/hr/g | < 0.001 deg/hr/g |
| Scale Factor Error (Long-term) | < 50 ppm | < 10 ppm |
| Angular Random Walk | < 0.005 deg/ (hr)1/2 | < 0.001 deg/ (hr)1/2 |
| Angular Cross-axis Sensitivity | < 0.1% | < 0.01% |
| Linear Acceleration Sensitivity | < 1e-6 rad/g | < 1e-7 rad/g |
| Alignment Calibration Stability | < 5 arc-sec | < 1 arc-sec |
| Angular Rate capability | > + 0.5 rad/s | |
| Angular Acceleration Capability | > + 0.5 rad/s2 | |
| Operating temperature range | -54 to 32 C | |
| Survivable temperature range | -60 to 71 C | |
| Radiation Hardness (total dose) | > 100 Krad | > 300 Krad |

The performance goals for lightweight, high efficiency gimbal motors are presented below are specifically tailored to support future space surveillance missions.

Performance Goals:

| | |
|---|---|
| Inertial Loads (elevation axis): | 5-6 IN-Lb-S2 |
| Inertial Loads (azimuth axis): | 15-16 In-Lb-S2 |
| Active travel range (elevation): | -1 to +81 degrees |
| Active travel range (azimuth): | +/- 185 degrees |
| Acceleration rate (each axis) | 2R/S2@2R/S |
| Positioning error: | > 0.005 degrees |
| Operational life: | > ten years. |
| Max Power requirements: | < 3.2 Amp (azimuth) and 1.7 Amp (elevation) |
| Friction torque: | < 3 In-Lb (elevation) & < 8 In-Lb (azimuth) |
| Structural stiffness: | Support a 40 Hz Servo |
| Operational temperature range: | -40 < T <170 degrees Fahrenheit |

Selected materials must not display outgassing characteristics greater than 1 percent total weight loss and 0.1 percent volatile condensable materials in a vacuum of 1X10-5 torr or less. The motor design capable of meeting the above criteria should be capable of being up sized or down sized to meet additional application requirements. Successful proposals will demonstrate a thorough knowledge of the current state-of-the-art in satellite sensor gimbal designs and requirements.

PHASE I: Develop a preliminary design for the proposed component or system. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate the offeror understands the physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how near-term goals will be met, at a minimum. Proof of concept hardware development and test is highly desirable. Proof of concept demonstration may be components or subscale demonstrators and used in conjunction with MS&A results to verify scaling laws and feasibility. This phase should make plans to further develop and exploit this technology in Phase II. Offerors are most strongly encouraged to work with system, payload, and/or GNC contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: Complete critical design of prototype component or system including all supporting MS&A. Fabricate prototype hardware (MEMS gyro - a minimum of two devices, preferably four, Gimbal motor – a minimum of one device, preferably two, other components – a minimum of one device) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system, payload, and/or GNC contractors.

PHASE III: Work with a commercial company or independently to develop and commercialize product(s) based on the technology developed in Phases I & II.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Miniaturized, lightweight components have application in the civilian aerospace market for both aircraft and spacecraft systems. High performance MEMS gyros have guidance applications in both manned and unmanned aircraft, munitions, missiles, and spacecraft. Other applications include vibration and motion control for robotic applications, such as precision manufacturing and motion-controlled cinematography processes, automotive control applications, and line of sight stabilization of laser crosslinks for high speed communications. Lightweight, high efficiency, precision gimbal motors also have application in areas such robotic manufacturing, laser crosslinks, and civilian gimbal applications such helicopter news cameras and specialized “fly along” camera systems for sporting events.

REFERENCES: 1. 528-2001 IEEE Standard for Inertial Sensor Terminology (Japanese translation published by the Japan Standards Association)

2. 529-1980 (R2000) IEEE Supplement for Strapdown Applications to IEEE Standard Specification Format Guide and Test Procedure for Single-Degree-of-Freedom Rate-Integrating Gyros

3. 671-1985 (R2003) IEEE Standard Specification Format Guide and Test Procedure for Nongyroscopic Inertial Angular Sensors: Jerk, Acceleration, Velocity, and Displacement

4. von Kemper, C., Verijenko, V., “Design, Analysis, and Construction of a Composite Camera Gimbal,” Composite Structures, v.54, no.2-3, p.379-388.

KEYWORDS: MEMS Gyroscope, inertial rate sensors, gimbal motors, Acquisition, Tracking and Pointing (ATP), beam control, line of sight (LOS) determination and control

MDA07-009 TITLE: <u>Advanced Interceptor Axial Propulsion and Miniature Divert and Attitude Control Systems (DACS)</u>

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: DV, DEP, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate advanced solid/liquid interceptor propulsion components and systems for atmospheric/ exo-atmospheric use, operational at the ambient temperature (-60 Deg F to 170 deg F). This topic seeks advanced axial propulsion and DACS as well as possibilities for combined/flexible propulsion systems. Criteria include low cost (<$200K), light weight (<10 Kg including fuel with delta V > 1,000 m/sec), high performance, fast reaction (<10 ms), and resistance to high temperature and high pressure (2000 psi) with minimum out-gassing. Novel concepts for lightweight DACS with high delta velocity (> 1,000 m/sec) and high thrust (> 5 gs) that enable large mass fraction (> 40% system mass fraction and 60% DACS mass fraction) are of special interest. The life expectancy of the all-up round >7 yrs.

DESCRIPTION: Advanced solid and liquid propellants that provide improved performance and reduced environmental impacts compared to traditional liquid propellants are needed. The increased combustion temperatures associated with advanced solid and liquid propulsion require more robust materials and processes, and propulsion systems with lifetimes commensurate with interceptor system operational requirements. Advanced techniques for propulsion components, such as nanotechnology, and materials such as ceramics and SiC to increase the operating temperature, reduce oxidation and erosion are sought. Desired materials include both composite and monolithic. High specific impulse and high density-specific impulse liquid propellants are of interest. In addition to temperature resistant materials, techniques for cooling components as are of needed (provided they are compatible with a light weight, low cost DACS). Proposals that address survivability of propulsion electronics in an interceptor radiation environment are also sought, especially for DACS electronics.
Despite recent progress, several technical propulsion challenges remain, including, but not limited to:
• Understanding the compatibility of ablative composites (tank/seal) materials in green & non-green liquid propellant environment (HAN, ADN, Hydrazine…).
• Demonstration of complex braided structures and integral assemblies for green & non-green liquid mono-propellants specific hardware.
• Development of light weight composite joining methods including high temperature brazing, ceramic bonding, ceramic metal bonding and metal liners.
• Enhanced matrix compositions that improve life for oxidizing environments at 2000 deg C and beyond to exploit emerging high performance propellant formulations
• Fiber and coatings with improved mechanical properties and oxidation resistance compared to current state of the art (SOTA).

PHASE I OBJECTIVES: Develop a design and a plan of approach for development for above stated objectives. Through analysis and M&S, identify approaches for potential solutions to the above listed challenges.

PHASE II OBJECTIVES: Implement one of the promising approaches identified during phase I. Fabricate a prototype that demonstrates the proof of concept. The demonstration should include materials compatibility at or above 2000Deg C. Offerrors are strongly encouraged to align their effort towards a relevant BMDS system and payload contractors to ensure technology transition.

PHASE III: The developed technology should have direct insertion potential into missile defense systems.

PRIVATE SECTOR COMMERCIALIZATION PONTENTIAL: The technologies developed under this SBIR topic should have applicability to automobile industry, unmanned vehicles etc.

REFERENCES: 1. George P. Sutton, “Rocket propulsion Elements; Introduction to Engineering of Rockets” 7th edition, John Willey &Sons, 2001.

KEYWORDS: Solid and liquid mono-propellants, DACS, Actuator, Hot gas generator, HAN, AND

MDA07-010 TITLE: Advanced Interceptor Guidance, Navigation and Control (GN&C) Components

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: DV, GM, KI, TH, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop, and demonstrate highly-integrated, compact, high-performance, lightweight GNC component technologies to include gyros, accelerometers, associated electronics and their integrated units (Inertial Reference Unit, Inertial Measurement Unit), with or without Global Positioning System augmentation, Advanced nonpropulsive interceptor control components are also sought. These technologies will support an integrated avionics suite and they will be used for insertion into spiral upgrades to current BMDS interceptor systems to enable advanced, agile interceptors to defeat various types of targets, mitigate the discrimination problem and defeat the asymmetric threat.

DESCRIPTION: This topic focuses on the gyros, accelerometers, IRU, IMU, associated electronics, and GPS augmentation of the avionics suite. GNC systems could benefit from improvements that lower cost, reduce size and weight, have lower sensitivity to shock and vibration, have wider bandwidth, larger dynamic range, higher data rates, and include external navigation updates such as GPS. BMDS interceptors are expensive. As interceptor systems upgrade toward longer-range capabilities along with increasing requirements for agility, processing power, and accuracy, a new GNC modular architecture, along with compact, inexpensive, advanced GNC components is needed. In addition, as the interceptor migrates toward a more flexible and agile vehicle, the size, weight, and performance requirements of the GNC components will be more challenging.

This SBIR topic solicits novel concepts and technologies in making GNC components (gyros, accelerometers, associated electronics etc.) low in cost, lightweight, compact, and of high performance. These technologies and the integrated package should have the architectural capability to easily change to suit the interceptor in which it will be used. The desired performance goals to guide the research are drift rates on the order of 0.1-2 deg/hr, ARW on the order of 0.1-0.002 deg/rt-hr, and data rates and bandwidths of multiple kHz to as high as 20 kHz. Weight for the overall system should be much less than 400 grams with volume much less than 30 cu. in. and a substantial cost reduction. The GNC components and integrated system must be able to withstand high shock and vibration upon missile lift-off and separation events, and during DACS operation, impose minimum operational requirements prior to launch, and operate in a thermal environment from -50 C to + 70 C. It should not be sensitive to Electro-magnetic Interference or prolonged storage at temperatures. Radiation hardness to >300krad is desirable. Capability for ten years of dormancy prior to launch is desirable. An integrated GPS receiver is desired to provide greater flexibility in launcher placement, improved guidance accuracy, and integrated operations, but the GNC suite should also be able to operate autonomously in a GPS-denial environment.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology and concepts to enhance avionics performance. Determine expected performance through extensive analysis/modeling effort. Identify technical risks and develop a risk mitigation plan.

PHASE II: Design, develop and characterize prototypes of the proposed technologies and demonstrate functionality. Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the proposed technologies in the fields of munitions and missile guidance, instrumentation for motion control, simulation & training, vehicle safety and personal navigation

REFERENCES: 1. S. Lyshevski, “MEMS and NEMS, systems, devices and structures”, CRC Pres, 2002

2. H.Helvajian, “Microengineering Aerospace Systems” The Aerospace Press, American Institute of Aeronautics and Astronautics, 1999.

3. P.Zarchan, Tactical and Strategic Missile Guidance, 3rd Edition,AIAA,1997

4. J. Soderkvist, “Micromachined Gyroscopes” 7th ICSS Sensors Actua., pp.638-41, 1994.

5. R. Dorf , Modern Control Systems 6th Edition, Addison Wesley, 1992

KEYWORDS: interceptor, avionics, gyros, accelerometer, electronics

MDA07-011 TITLE: Advanced Synergistic Structures for Interceptor Kill Vehicles

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: AB, DV GM, KI, TH, SS, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop technology for an interceptor Kill Vehicle (KV) that integrates disparate components into the load bearing structure to increase the performance of the KV.

DESCRIPTION: The phrase “Synergistic Structures” in this context refers to Structures with multiple functions (e.g., fuel tanks or batteries that function as load-bearing KV structure and/or protect against hostile environment) or structures with embedded components (e.g., electrical, optical, power, cabling, propulsion, sub-structures, isolation, etc). The synnergy must not compromise the integrity of the interceptor. The MDA has funded numerous technology development programs that could be applied toward KVs. However, many of these efforts focused on an individual component without the consideration of combining components into a system to save mass, volume, and ensure structural integrity. The MDA is interested in developing revolutionary and evolutionary KV technologies that will significantly improve key performance parameters (speed, volume, mass, accuracy, agility, etc.). In recent years, a number of new technologies have emerged (new materials, nano-research, component/electronic miniaturization, enhanced kill effects, etc.) that make it feasible to integrate components in a system without degradation of other subsystems. This effort will focus on the development of embedded components of previously independent structures/subsystems with considerations to the following: radiation shielding, structural stability, harmonics, mass, reduced part count, enhanced lethality, and reduced volume. Additionally, the structural system must be designed to the operational environment (temperature variations, high acoustic levels, maneuvering loads, high shock loads, HAENS level 2, and severe vibration loads). Proposals should provide sufficient detail to allow the evaluation team to ascertain the potential benefits and risks associated with the concept and describe the system-level benefits.

PHASE I: Develop initial design concept; conduct analytical and experimental efforts to demonstrate proof-of-principle; develop preliminary design complete with documentation that will provide proof-of-functionality; and model or produce/demonstrate “breadboard operational prototype” to ensure proof of basic design concept. Proposed concepts should be modeled with representative KV-type environment. The contractor will provide any embedded components for models, breadboards, etc. Simulated embedded components may be substitued for actual components if their use is substantiated by analyses. The contractor will develop a Phase II strategy plan that includes (but not limited to) development and integration strategy, potential demonstration opportunities, program schedule, and estimated costs.

PHASE II: Design and fabricate a prototype structural concept that could be demonstrated in a representative KV environment. The goal is to transition and commercialize this technology by developing working relationships with the relevant BMDS systems and contractors. The contractor will provide any embedded components for prototypes.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing. The contractor will provide any embedded components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for highly integrated/synergistic structures is immense in the aerospace, automobile, and infrastructure industries.

REFERENCES: 1. Starr, A.F., et al., “Fabrication and Characterization of a Negative-Index Composite Metamaterial,” Physical Review B, Vol. 70, 113102 (2004)

2. Adams, J.H., “Radiation Shielding Materials,” AIAA 2001-0326, 39th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, 8 January 2001.

3. Wilson, J.W., et al, “E-Beam-Cure Fabrication Polymer Fiber/Matrix Composites for Multifunctional Radiation Shielding,” AIAA 2004-6029, Space 2004 Conference and Exhibit, San Diego, CA, 28-30 September 2004.

4. Thostenson, E.T., Ren, Z, Chou T-W, “Advances in the science and technology of carbon nanotubes and their composite: a review” Composites Science and Technology, 61, pages 1899-1912, 2001

5. Ruffin, P. B. “Nanotechnology for Missiles” Quantum Sensing and Nanophotonic Devices, Proc. Of SPIE, Vol. 5359, Bellingham WA, 2004

KEYWORDS: Synergistic Structures, Integrated Structures, Kill Vehicles, Radiation Shielding, Communications, Optics, Composite Materials, Nano-Materials

MDA07-012 TITLE: Interceptor Algorithms

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: AB, DV, TH, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The evolution of advanced threats, and the development of ballistic missile defenses to keep pace with them, demands interceptor algorithms of ever greater sophistication. This SBIR topic will develop and demonstrate advanced Guidance, Navigation and Control (GNC), and data processing, kill vehicle (KV) discrimination algorithms. Multiple kill vehicle (MKV) weapon-target assignment and collision avoidance algorithms are needed for enhanced interceptor and KV agility and guidance flexibility. Performance goals include the minimization of the interceptor control energy, miss distance and reliance on a priori data. Consider algorithms to support operations in a man made hostile environment.

DESCRIPTION: GNC algorithms include interceptor and KV guidance algorithms (including estimators, guidance laws, and controllers) for kinetic kill intercept. Guidance for both command-guided interceptor fly out and autonomous KV end game homing are needed, and seamless transition between the two phases is desirable. Interceptor signal processing algorithms comprises advanced techniques for converting KV seeker measurements to signals for KV target acquisition, discrimination and homing. M on N algorithms are needed for assigning MKVs to multiple targets while simultaneously avoiding mutual MKV collisions and target blocking.

The objective of the GNC portion of this topic is to demonstrate novel approaches to algorithms in the following areas: (1) guidance, (2) estimation, and (3) control for a specified missile concept. Responses may concentrate in any one of the areas or preferably provide an integrated synthesis approach. Approaches that enhance the probability of successful kill vehicle-(weapon)-to-target paring for multiple kill vehicle missiles are preferred. If possible, algorithms should support dual sensor systems such as combined passive and active seeker kill vehicles.

Proposed design methodologies must start with a configuration description and set of specifications for vehicle, sensors and actuators. The design methodologies must incorporate any novel approaches into an integrated design including the various missile components.

PHASE I: Develop the algorithms that will provide a high probability of kill against various threats. Demonstrate performance in an integrated M&S environment of sufficient fidelity.

PHASE II:  Optimize results of Phase I, evaluate and mature algorithms developed in Phase I and validate the algorithms.  The goal is to transition and commercialize this technology by developing working relationships with the relevant BMDS systems and contractors.

PHASE III:  The algorithms developed under the Phase II effort will be inserted the acquisition process for missile defense systems.  Offerors are strongly encouraged to work with MDA system contractors to understand the system requirements, to help ensure applicability of their effort, and to work towards technology transition.

PRIVATE SECTOR COMMERCIAL POTENTIAL:  Advanced non-linear GNC algorithm development has applications in the commercial airline industry, unmanned aerial vehicles, robotics, rotorcrafts, etc.

REFERENCES: 1. Dyer, W. R., “Boost Phase Homing Guidance,” 2003 Multinational Ballistic Missile Defense Conference, 2003.

2. Ben-Asher, Yaseh,  Advances in Missile Guidance Theory,  AIAA, 1998

3. Zarchan P., Tactical and Strategic Missile Guidance, 3rd Edition, AIAA, 1997

4. Chadwick, W. R., “Reentry Flight Dynamics of a Non-Separating Tactical Ballistic Missile,” Proceedings of AIAA/BMDO Interceptor Technology Conference, San Diego, CA, 1994.

5. Zarchan, P., “Proportional Navigation and Weaving Targets,” Journal of Guidance, Control, and Dynamics, Vol. 18, No. 5, 1995, pp. 969-974.

6. Cloutier, J. R., D¡¦Souza, C. N., and Mracek, C. P., “Nonlinear Regulation and Nonlinear H-Infinity  Control Via the State-Dependent Riccati Equation Technique,”  Proceedings of the International Conference on Nonlinear Problems in Aviation and Aerospace, Daytona Beach, FL, May 1996

7. Mracek, C.P. and Cloutier, J.R., “Missile Longitudinal Autopilot Design using the State Dependent Riccati Equation Method,” Proceedings of the 1997 American Control Conference, June 4 - 6, Albuquerque, NM.

8. Cloutier, J.R., “State-Dependent Riccati Equation Techniques: An Overview,” Proceedings of the 1997 American Control Conference, June 4 - 6, Albuquerque, NM.

9. Xin, M., Balakrishnan, S. N., and Ohlmeyer, E. J., “Nonlinear Missile Autopilot Design with Theta-D Technique,” AIAA Journal of Guidance, Control and Dynamics, Vol. 27, No. 3, May-June 2004.

10.  Menon, P. K. and Ohlmeyer, E. J., “Computer-Aided Synthesis of Nonlinear Autopilots for Missiles,” Journal of Non-linear Studies − Special Issue on Control in Defense Systems, Vol. 11, No. 2, 2004.

11. Menon, P. K., Sweriduk, G. D. and Ohlmeyer, E. J., “Optimal Fixed-Interval Integrated Guidance-Control Laws for Hit-to-Kill Missiles,” AIAA Guidance, Navigation and Control Conference, Austin, TX, 11-14 August, 2003.

12. Menon, P. K. and Ohlmeyer, E. J., “Nonlinear Integrated Guidance-Control Laws for Homing Missiles,” AIAA Guidance, Navigation & Control Conference, Montreal, Canada, 6-9 August, 2001.

13. Menon, P. K. and Ohlmeyer, E. J., “Integrated Design of Agile Missile Guidance and Control Systems,” IFAC Journal of Control Engineering Practice, Special Issue on Control in Defense Systems, Vol. 9, 2001.

KEYWORDS: Control Algorithms, Estimation, Guidance, Data Processing, Flight Control, Interceptors, Neural Network, Optimal Control, Navigation

MDA07-013 TITLE: Interceptor Avionics

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: DV, GM, KI, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The objective of this research and development effort is to encourage the genesis of innovative, high performance avionics systems and components that will enhance the capability of current and future interceptors in a hostile environment.

DESCRIPTION: Avionics systems currently used in the BMDS interceptors are still too expensive, bulky, and heavy. They provide limited bandwidth, power, and range and are sensitive to shock and vibration. Next generation agile interceptor designs with advanced seeker and propulsion systems will demand further performance enhancements to support new missions while simultaneously reducing weight and power dissipation. Interceptor Avionics, for this topic, includes the seeker signal/image processors, flight computer, interceptor communication system, internal wiring/wireless interconnectivity, connectors, networks, and interceptor power sources and conditioning. Anti-tamper processes, techniques, and materials are desired for interceptor avionics to prevent exploitation of our systems. Improvements in the avionics data transmission, power generation/distribution, processing, and system architecture are required to enable interceptor advancements.

Special emphasis on GN&C hardware components is under a separate topic and is not under Avionics for this topic. However since integration (the physical environment, electromagnetic compatibility, vibration, system safety, and quality) is an important factor in the design and development of interceptor avionics (in addition to), the implications of any onboard GN&C system on the rest of the avionics should be an important consideration. A barrier to interceptor system design is incompatible components and subsystems primarily due to disparate interface designs. Therefore, plug and play/open system approaches are solicited.

Large format, multi-color seekers may require more than 100 million pixels per second, and will benefit from any technology that would reduce that demand through on-focal plane processing or intelligent, flexible data compression hardware/firmware. The cost of interceptor flight computers can comprise a significant portion of the overall cost of the interceptor. Proposed designs should strive for twice the performance at half the cost. Therefore, performance goals for the advanced designs should be in the range of 20-200 mega pixels per second, with processor speeds in the multi-gigahertz range, IMU data rates in the 20 kHz range, and a cost target under 25% of overall missile cost.

Power source and distribution systems to provide 1.0 KW for carrier vehicle (CV) and 0.5 Watt for kill vehicle (KV) with the total mass of such power distribution systems not to exceed 10% mass of the CV/KV combined. Onboard power generation during the down times using available energy sources may be an area of investigation. Further improvements in power source technologies are needed to accommodate highly agile interceptor power requirements. Advanced electronic packaging approaches to maximize volumetric efficiency greater than 90% are needed to remedy some thermal management issues.

Advanced secure interceptor communication systems (<200 grams and 3”x2”x0.5” in size) will be required for future systems. Interceptor communications must be able to transmit in radiation environments and establish link (s) within 50 km with peak transmission power of <5 Watts. They must also be able to receive updates at ranges up to 1000 km.

Methods to improve interceptor diagnostics/prognostics within avionics architecture are solicited. Additionally, internal data busses, cabling, and connectors are sources functional faults. Access to and checkout of these avionics components is important Elimination of cables and connectors via wireless connectivity is also desirable.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance avionics performance. Proposed designs should strive for twice the performance at half the cost of current technology, and strongly suggest a growth opportunity for further performance increases and cost reduction.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop and execute a plan to manufacture the avionics system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed avionics technology growth areas would have applicability to automobile industry, communication satellites, and the computer industry.

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KEYWORDS: interceptor, avionics, communication, power, signal processors, data processors, electronics.

MDA07-014 TITLE: Radiation Hard Interceptor Components Test Methods for Missile Defense

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: AB, DV, GM, DEP, TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: The overall objective of this effort is to investigate and/or validate the capability of MDA active or passive optical telescope subsystems in a realistic radiation environment. These interceptor subsystems must be able to operate reliably in a Ballistic Missile Defense System (BMDS) interceptor environment without a negative impact on weight, performance, or reliability. The radiation assessment includes passive focal plane array (FPA) sensor designs, signal processing techniques, environmental mitigation approaches, digital and analog electronics, and other active component reliability.

DESCRIPTION: Current interceptor FPAs, analog-to-digital (A/D), D/A converters, memory, processors, and other avionics components need improvement to increase reliability in hostile radiation environments. MDA systems must function reliably when exposed to background radiation from space and radiation resulting from nuclear events (including x-ray, prompt and persistent gamma, single event effects, total ionizing dose, space radiation, and optical flash). Limitations on mass in a missile system (especially lightweight kill vehicles) preclude exclusive reliance on traditional shielding methods as a means of countering the adverse effects of radiation. MDA is seeking the development of innovative sensor concepts that are radiation-hard either by process, by design, by architecture or by a combination of these approaches. It is expected such hardening will allow sensors to survive and reliably operate in BMDS mission environments without increasing weight or decreasing performance. Furthermore, such sensors must be appropriately tested both for survival and operability. MDA is seeking development of appropriate test systems and approaches that will support implementation of the hardened technology within the MDA sensors. Technical areas of interest include: novel sensor concepts including FPA and processing concepts that enable operability while controlling degradation, test methods and hardware, and production concepts. The use of Technology Readiness Levels to describe current technology maturity will be helpful in evaluating the planned effort. This topic's focus is on innovations that can be used in improving confidence in missile defense interceptors' performance.

PHASE I: In Phase I, we seek innovative concepts that address one of the components and a reference architecture based on that component capable of reliable operation in the BMDS system for its projected mission life. Conduct research and experimental efforts to identify, investigate, and demonstrate unique sensor designs, test methods and test hardware and/or production process changes that address reliable operation of BMDS interceptors in perturbed environments consistent with High Altitude Nuclear Bursts as described in Reference 2 or prolonged natural space radiation. Determine feasibility of inserting hardening and/or evaluating radiation hardened missile sensors using proposed concepts without significantly impacting sensor mass, cost and producibility. Develop an experimental approach that demonstrates the sensor radiation hardness capability of the treatment. Wherever possible, modeling, simulation, analysis, and/or testing should be performed to support conclusions. Consider implications for practical implementation of proposed concepts. Offerors are encouraged to work with system and payload contractors and test providers to help ensure relevance of their efforts and begin work towards technology transition. Note that each proposal may address only one component, but that offerors may submit multiple proposals.

PHASE II: The approach must be flexible for use in a wide range of mission designs. Using the results of the technology development in Phase I, implement, test and verify the proposed concept in a prototype to demonstrate feasibility and efficacy. Validation would include, but not be limited to, BMDS simulations, operation in test-beds, operation in a demonstration sub-system, and/or radiation testing. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end the offerors are encouraged to further seek partnerships with system primes or interceptor vendors as appropriate. The offerors should strongly pursue funded (if possible) co-support from system primes (and their subcontractors), as these are strong indicators of relevance of the proposed work.

PHASE III: In this phase, the contractor will produce components to fully comply with the established requirements for use in MDA interceptor and DoD systems, or commercial applications. The degree to which the offeror can make such suppliers attracted to their solution is a strong consideration in gauging viability of their approach.

PRIVATE SECTOR COMMERCIAL POTENTIAL: All of this work applies to the larger class of satellite and missile systems, which include commercial satellites and launch vehicles. As we find that ground systems are experiencing single-event upsets, it will soon be true that even they will require the solutions called for in this topic, particularly high-reliability systems, whose failure has life-and-death consequences.

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KEYWORDS: radiation effects on electronics, radiation hardening, sensors, hardware test methods

MDA07-015 TITLE: Interceptor Seekers

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DV, GM, TH, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop and demonstrate highly integrated, compact, high performance, lightweight interceptor seeker technologies to include advanced active, passive and dual-mode seekers, sensors, and seeker components, for RF and EO/IR seekers. These technologies will be part of an integrated seeker suite and they will be used for insertion into spiral upgrades to current BMDS interceptor systems to enable advanced, agile interceptors to defeat various targets, facilitate discrimination, and defeat the asymmetric threat. A primary objective is for long range detection, tracking and intercept of all Ballistic Missile Defense (BMD) endo- and exo-atmospheric targets.

DESCRIPTION: Key functions of a missile defense interceptor are to detect, track, discriminate, and engage threat objects. Those functions rely on seeker technology to measure line of sight angle, and in some cases, range and range rate, to intercept targets successfully. They may also measure discrimination data such as IR radiance in multiple bands, target images in several dimensions, and dynamics. Both active and passive seekers, and the combination of them in a gimbal or strapdown (preferred) configuration are critical for future discrimination seekers. Operation in a hostile environment is desirable.

This topic calls for passive and active interceptor seekers and their components that will be able to detect, track, and discriminate targets at longer ranges within wider fields of view and with greater measurement accuracy. Passive infrared seekers to be developed should have the capabilities of increased sensitivity, improved uniformity and operability, reduced readout noise, improved resolution, longer cutoff wavelengths (out to 14 mm), large formats (in excess of 256 x256), and high operating temperatures (as high as possible). Multi-color focal plane arrays (FPAs) that have two to four wavebands (i.e., MW/LW, LW/VLW or MW/LW/LW) are desirable for discrimination by measuring the target thermal profile. Active seekers, to include laser radar (ladar) and RF, are also to be considered. The innovative concepts, components and technologies to be developed under this topic include dual-mode active/passive seekers and their components, sensor fusion, integration, on FPA and near FPA data processing, data rate reduction, and dual Field of View lenses (to enable zoomable lens).

Improvements are also sought for interceptor light-weight, compact, rugged LADAR components. Transmitters with chip-scale-packaging, scalable sources for increased ranging are needed. Compact and efficient fiber sources and integrated systems through advances in slab and solid state lasers demonstrating high power efficiency are also sought. Components of interest are also fast steering mirrors, and shock and vibration mitigation systems. Full aperture, servo-controlled, 2-axis FOR mirror with a closed-loop bandwidth of >100 Hz and < 10 micro-radian error is desired; a small, servo-controlled, 2-axis laser pointing mirror with a closed-loop bandwidth of at least 10 kHz and < 1 microradian precision is desired – non-mechanical approaches will be also be considered. Shock and vibration mitigation techniques (active/passive) may rely on smart structures which incorporate sensing and PZT-like reaction, or other passive/active techniques which retain the optical system rigidity and pointing knowledge. Innovations in small, low cost, rugged, high-power RF seekers and RF seeker components are also sought for millimeter and shorter wavelengths. Technology improvements are needed in lightweight, high efficiency solid-state or tube sources, frequency combiners, radomes, antenna design, and integrated electronics. Pulsed radar techniques such as coupled oscillator beam steering, and pulse compression in order to realize low cost, compact antennas with maximum resolution are of interest.

PHASE I: Research, quantitatively analyze, and develop a conceptual design and assess the feasibility of an active, passive, or dual-mode seeker system or component. In the case of a component it is desirable (budget permitting) that a prototype be developed and demonstrated.

PHASE II: Design, develop, and characterize a prototype of the active, passive, or dual-mode seeker system (or component) and demonstrate its functionality. Investigate private sector applications along with military uses of key components developed in Phase II.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES: 1. W. Dyer, W. Reeves, and G. Dezenberg, “The Advanced Discriminating Interceptor”, AIAA Missile Science Conference Proceedings, 1994.

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KEYWORDS: Remote Sensing, Multispectral Imaging, Discrimination, IR Detectors, Spectral Characteristics of Materials

MDA07-016 TITLE: <u>Aerodynamic Drag and Lift Characteristics for Irregularly-Shaped Intercept Fragments</u>

TECHNOLOGY AREAS: Battlespace, Weapons

ACQUISITION PROGRAM: DES, DEE

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OBJECTIVE: Develop techniques to measure and/or predict aerodynamic drag and lift characteristics for irregularly-shaped intercept fragments.

DESCRIPTION: Missile defense intercepts produce a wide variety of irregularly-shaped debris fragments. Methods are required to model trajectory propagation for these fragments. While fragment drag characteristics have been measured and modeled (see REFERENCES) to a limited extent, data and models are not available for fragment lift characteristics. Such drag and lift characteristics can be critical for predicting the trajectories and ground impacts for debris fragments.

PHASE I: Develop and demonstrate an approach for measuring and/or predicting drag and lift characteristics of fragments collected from missile engagements. Samples of such fragments will be provided. The approach should address the correlation of drag and lift characteristics and the correlation of these characteristics to other fragment properties for a full spectrum of flow regimes including free molecular, hypersonic, supersonic, transonic, and subsonic. Magnitude, direction, and variability of the lift characteristics shall be included.

PHASE II: Perform fragment drag and lift measurements and/or predictions using the approach developed in Phase I. A wide range of fragment sizes, shapes, materials, and masses shall be addressed. A wide range of Mach Numbers and/or Reynolds Numbers shall also be addressed to cover the expected range of flow regimes. The resulting data shall be incorporated into a model suitable for implementation in other debris simulations.

PHASE III: Expand data and/or models to debris related to commercial space launches and commercial satellites.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This information could be applied to predictions of where debris from failed commercial space launches or commercial satellites will impact the Earth.

REFERENCES: 1. McCleskey, F., Drag Coefficients for Irregular Fragments, Kilkeary, Scott & Associates, Inc., NSWC TR 87-89, Feb 1988.

2. Sommers, W.J, et al., Radar Cross Sections and Ballistic Coefficients of Fragments From Impacts with Complex, Full-Scale Targets, Int. J. Impact Engng, 20, 1997, 753-764.

3. Hoerner, S.F., Fluid-Dynamic Drag: Practical Information on Aerodynamic Drag and Hydrodynamic Resistance, Published by Author, 1965.

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KEYWORDS: Fragments, Debris, Lift, Aerodynamics, Propagation, Drag, Trajectory

MDA07-017 TITLE: Develop Consistent First-Principles Earthshine and Skyshine Ultraviolet, Visible, and Infrared Computer Models

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: DES

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate Earthshine and Skyshine ultraviolet, visible, and infrared computer models consistent and compatible with existing comprehensive radiation transport codes.

DESCRIPTION: MDA seeks accurate, robust, and fast first-principles computer models of earthshine and skyshine radiation for the ultraviolet, visible, and infrared wavelength ranges. Missile detection can be impacted by earth, cloud, and sky radiation. To optimize sensors, it is crucial to understand how cloud, earthlimb, and sky backgrounds contribute to wanted or unwanted irradiance that illuminate the aperature of a sensor. It is therefore necessary to understand and model the various naturally occurring reflective, absorptive, and emissive processes that contribute to the irradiance field of a sensor. Global earthshine calculations should account for upwelling solar and lunar reflections from realistic earth materials and clouds. Effects due to thermal and infrared emissions from the hard earth as well as high altitude earthlimb emissions (OH and other molecules) should be included. Effects due to direct, reflected, and emitted downwelling skyshine from lunar and celestial objects should be included. Other effects include reflected solar/lunar/sky radiance, solar/lunar scattering, diffuse solar radiance, solar/lunar/celestial and thermal sky shine, solar/lunar and thermal path radiance, earth, cloud, earthlimb, and background radiance, and non-local thermodynamic effects. Methods will account also for hemispherical, isotropic and non-isotropic propagation effects. Desired output is the spectral irradiance at user specified altitudes. The models should be consistent and compatible with existing all-altitude radiation transport codes, such as the Air Force SAMM2 model (http://www.vs.afrl.af.mil/ProductLines/IR-Clutter/). The line-of-sight radiance and transmission algorithm of SAMM2 is available as government furnished software which may be used as a core radiation transport building block for the earth and skyshine models.

PHASE I: The contractor will demonstrate a robust architecture for accurately and rapidly calculating earthshine/skyshine effects in the UV/visible/IR bands. Provide a plan that will lead to model validation.

PHASE II: Develop earthshine/skyshine ultraviolet, visible, and infrared models and computer algorithms consistent and compatible with existing comprehensive radiation transport codes in accord with the above description. Validate the models.

PHASE III: Transition the architecture and models developed under Phase 2 to a robust and comprehensive military/commercial satellite assessment and diagnostic tool. Provide design specification tools for commercial space imagers.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Cloud radiation is crucial for cloud scene simulation and weather forecasting. Cloud, earthlimb, and sky radiation could be applied to specification of impacts of natural illumination sources on commercial satellite sensors. First and second order effects and their mitigation could be specified for remote sensing applications that might include agricultural surveys, traffic control, search and rescue missions and wildlife population counts.

REFERENCES: 1. R.L. Sundberg, J. Gruninger, P. De, J.H. Brown, “Infrared Radiance Fluctuations in the Upper Atmosphere”, SPIE Propagation and Imaging Conference - Characterization and Propagation of Sources and Backgrounds IV, SPIE Proceedings Vol. 2223, Orlando, FL, April 6-7, 1994.

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KEYWORDS: radiation transport, earthshine, skyshine, environment, clouds, airglow

MDA07-018 TITLE: <u>High Fidelity Missile Hardbody Plume Interaction Modeling</u>

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: AB, GM, KI, SS, MK, SN, DEE

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE:  The ballistic missile defense system requires sensors to detect and track threat missile from launch to RV impact.  Tracking these threats utilizes the plume during the boost portion of flight and then utilizes the hardbody signature after burnout.  Current numerical modeling techniques predict the missile’s aero-thermal heating and plume signatures using independent flowfield methods with no coupling or interactions.  The objective of this effort is to examine innovative techniques and processes to accurately predict both the missile hardbody and plume flowfields simultaneously using a common flowfield solver from launch to impact.

DESCRIPTION:  Current missile aerothermal heating methods embedded in codes such as ATAP and OSC have been around for many years but do not include complete propulsion and plume-induced heating effects to the hardbody (i.e. nozzles, base regions, fins, etc.) during boost phase.  The current JANNAF exhaust plume flowfield models (SPF, CHARM, SOCRATES) have methods to account for the flow over the missile body, but neglect the missile’s thermal soak for accurate prediction of hardbody temperatures during a missiles flight.  Both the current hardbody and plume flowfield codes include numerical methods that account for continuum, transitional, and rarefield flow regimes but are completely uncoupled to each other.  In addition, the current tools were originally developed for use on main frame computers and do not take advantages of modern parallel computer architectures.  This effort will explore advanced numerical techniques such as computational fluid dynamics and direct simulation Monte Carlo models that fully-couple the missile’s real surface characteristics (tanks, nozzles, fins, material layout, etc..) to more accurately compute the missile system’s complete flowfield and thermal temperature properties.  Alternative methods using weakly coupled or one-way coupled approaches are also of interest as these represent less compute-intensive solutions.

PHASE I:  During Phase I, the important plume-hardbody missile system interactions which impact hardbody signatures will be identified and prioritized over a missiles entire trajectory.  Once prioritized, one of the important plume-missile hardbody interactions will be selected and demonstrated. A case above 90 Km is of most interest to demonstrate this capability. For example, hardbody thermal properties with and without the hot nozzle interactions will be modeled and compared.  In addition, an assessment shall be made on the advantages/disadvantages of using simplified methods (e.g. one-way coupling) to predict missile signatures over the use of state-of-the-art fully coupled methods: speed versus accuracy shall be addressed.  Maximum practical use of existing software for both continuum and rarefied flow regimes is desired to reduce development and validation costs.

PHASE II:  The architecture for a code shall be developed which shall incorporate the key plume-hardbody interaction phenomena, as identified in Phase I.  They should also take advantage of the multiprocessor environment, either in a parallel or distributed manner, if at all feasible under this Phase of work.  Demonstration cases shall be run which (1) compare results obtained in Phase I and the same case run developed under the new Phase II code architecture, and (2) illustrate the effects of several other plume-hardbody interaction features.  Finally, delivery of the documentation, software and validation/demonstrations shall be completed.

PHASE III:  This phase shall be directed towards preparing the code developed under Phase II for distribution to the user community.  Key milestones for this phase shall include (1) validation and verification, (2) investigate and mitigate runtime issues related to the varied systems of interest, and (3) interface with the signature generation code FLITES and (4) conducting workshops and training sessions for the MDA user community.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The design and development of current and next generation space launch vehicles will strongly benefit from this integrated plume-hardbody interaction capability. This new advanced capability will be applicable from sea-level to burnout for use in rocket engine performance prediction, base heating effects, nozzle heat transfer design and plume forces for commercial space launch vehicles.  1996 report titled Commercial Space Launch Systems presents recommended requirements of the commercial spacecraft and space launch industries for the next generation of space launch systems. It was prepared by the Commercial Space Transportation Advisory Committee (COMSTAC), which advises the Secretary of Transportation on commercial space industry issues. This report supersedes the "Commercial Space Launch System Requirements", dated 5 April 1993 (reference 1). The COMSTAC has consistently urged that commercial requirements for launch services be included in the design basis of the next launch system developed by the U.S. Government for access to space for its security and civil science payloads. The COMSTAC believes that developing the next generation launch systems based on requirements which include those of the commercial satellite industry ensures a substantial commercial user base that would result in the cost of government launch services being substantially less than if the launch systems were optimized for Government payloads only. This report is intended to be used as a source of the commercial space launch industry requirements for future launch systems.

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KEYWORDS: transitional flow; plumes; boost phase signatures; high altitude; high thrust engines; CFD; DSMC; hybrid; continuum breakdown; bow shock; two-phase flow; reacting flow

MDA07-019 TITLE: Hypervelocity Intercept Modeling with First-Principle, Physics-Based Tools

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: DV, DES, DEE

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop techniques and tools for high-fidelity, first-principle, physics-based modeling of damage and debris from hypervelocity missile defense intercepts and use these tools to generate data sets to support the development and validation of fast-running algorithms.

DESCRIPTION: A limited number of missile defense intercept tests have been performed relative to the large matrix of potential interceptors, targets, geometries, and closing velocities. And these tests typically have limitations with respect to the quantity and quality of damage and debris data that can be reasonably collected. So while such data are critical to support the development and validation of fast-running intercept damage and debris algorithms, they are not sufficient to support the full scope of the requirements for such algorithms.

PHASE I: Develop and demonstrate an approach for modeling damage and debris from missile defense intercepts using high-fidelity, first-principle, physics-based tools. Such tools must capture both hydrodynamic and structural response regimes and be capable of modeling intercepts from 1-15 km/s. These tools must be able to model the response of all typical aerospace materials as well as of high explosives. These tools must be capable of providing data on the size, shape, mass, and velocity of debris fragments for a wide range of debris sizes. Tracking early time fracture response, quantifying mass deflection/channeling due to impact with significant forward structures, and payload lethality are also required. Demonstration will include modeling previously performed intercepts and comparing numerical results to collected empirical data.

PHASE II: Using the approaches developed and demonstrated in Phase I, prepare the high-fidelity, first-principle, physics-based tools and use these tools to generate damage and debris data sets for a wide range of interceptor, targets, geometries, and closing velocities. These numerical results will be used to complement empirical results in the development and validation of fast-running intercept damage and debris algorithms.

PHASE III: Expand tools to address damage and debris from space collisions involving resident space objects.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This information could be applied to predictions of damage and debris from space collisions and how such data might affect commercial satellites.

REFERENCES: 1. McGlaun, J.M., et al., CTH User's Manual and Input Instructions, Sandia National Laboratory Report SAND88-0523, 1988.

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4. Trucano, T.G., et al., Fragmentation Statistics from Eulerian Hydrocode Calculations, Int. J. Impact Engng, 10, 1990, 587-600.

KEYWORDS: Fragments, Debris, Intercept, Hydrocode, Lethality

MDA07-020 TITLE: <u>Improvements to the BMDS Hit-to-Kill Lethality Predictive Toolset</u>

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: DV, MK, DEE

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: This SBIR topic calls for improvements in two critical lethality-modeling and code development areas: the fragment loading modeling and high explosive modeling for non-shock to detonation transitions.

DESCRIPTION: Success of the BMDS program is based on kinetic hit-to-kill intercept of incoming threats carrying nuclear, explosive, or chemical/biological warheads. Understanding the phenomenology of the BMDS kinetic intercepts during impact and predicting the outcome of the event through computer simulations is a key to a successful and affordable BMDS. This understanding is often common across many areas of technology, not just BMD, such as space resource allocations and non-military investigations involving explosive devices. Over the years, the BMD community has developed several computer models and has applied them to BMDS lethality issues. Similar methodologies and databases have been developed for other organizations. For example, the FBI conducts explosive testing and builds database and models to aid investigations involving explosives. Due to the complexity of the physics involved, there are necessary improvements to be made to the codes to provide decision makers with trustworthy answers. Improvements are required in two critical lethality-modeling and code development areas: the fragment loading modeling and high explosive modeling for non-shock to detonation transitions. Both areas of development will enable technologies in government and private sector by maturing modeling and simulation methodologies common across many high technology disciplines, including but not limited to linear and non-linear computational methods, high energy and high strain rate problem solutions, and innovative closed form analytic mathematical solutions. Such technological advances could support many military and industrial applications.

Examples include micrometeriod or space debris impacts on space structures, explosives investigations, ballistic missile intercepts, structural testing involving explosives, and use of explosives in military and non-military applications, such as mining.
1. Fragment Flood Loading: Fast running penetration algorithms (e.g., FATEPEN, TATE, or Walker-Anderson) treat only single fragment events mainly in the rigid and steady state penetration regimes. After-flow penetration effects for single fragment/rods are poorly characterized. Additionally, multiple impacts, regardless of spacing or timing, cannot be evaluated using such codes. However, they can be simulated using hydrocodes such as CTH. When a large number of fragments impact in near vicinity of each other (i.e., fragment flood loading) a more vigorous reaction due to interacting penetration channels is possible. This physics of this synergistic event is not well characterized. Limited test data suggest that such synergies may result in larger and deeper craters in hardened structures, such as missile aeroshells, tank armor, and space structures. Furthermore, the structure itself can be so weakened by the numerous voids that it may also fail structurally. A better understanding of this phenomenology will aid design engineers as well as effectiveness assessment testing and analysis.
2. High Explosive Modeling Techniques for Non-Shock to Detonation Transitions: There is a need to develop a framework for modeling, within high fidelity computational tools, non-shock to detonation transition of high explosive from various stimuli. A primary kill mechanism against targets containing high explosive is shock to detonation transition (SDT) of the explosive load. However, predictive capabilities for reactive events of non-SDT nature such as unknown-to-detonation (XDT) and deflagration-to-detonation (DDT) pose significant challenges to the modeling community. The explosives are composed of constituents that generally include multiple organic crystals, metal particles, and organic binders. Theory from several physical and chemical disciplines is necessary to predict the overall behavior of the materials. These include the bulk mechanical response of the explosive, including their failure and combustion shock characteristics. A major requirement is the ability to conduct large-scale (30 to 50 million elements) computations. A capability to model explosive reaction beyond SDT will greatly increase the predictive capability of these codes and aid development of innovative closed form solutions of shock related problems.
This physics of lower energy reactions is not well characterized. Limited test data exists for these events and modeling techniques are not well validated. A better understanding of this phenomenology will aid design engineers as well as effectiveness assessment testing and analysis. Products such as dial-a-yield weapons could benefit greatly from this technology. Federal and/or international investigations of events where explosives with lower per mass energies have been used could benefit greatly from this technology.

PHASE I: Develop the necessary analytical tools to demonstrate proof-of-principle of the proposed technology to enhance the performance of lethality algorithms. Determine expected performance through appropriate analysis/modeling efforts. Develop a comprehensive plan to implement the proposed technology improvements and strawman test programs. Identify technical issues and develop issue resolution plans.

PHASE II: Implement the proposed plans, verify that new software meets design goals, and use actual data from relevant test activities and events to validate the code improvements. Compare and assess new predictive capability against results from other codes. Offer explanations when results differ. Demonstrate applicability to both selected military and commercial applications. Draft documentation as needed to support the product and deliver these products, along with baseline code and compilation tools, to the government and cognizant authorities in the military and industry.

PHASE III DUAL-USE APPLICATIONS: Once fully developed, the modular coded algorithms will be integrated into a product that can be used across a broad spectrum of applications to support an entire defense, intelligence, commercial, and homeland security applications. Such applications could include, but is not limited to support to missile agencies, energy departments, the Homeland Defense department, intelligence services, and federal investigation services. The methodologies developed in this effort can serve many applications where energetic materials are used, as well as where high rate kinetics are involved, such as ballistic missile intercepts, ground vehicle impacts, space asset vulnerability, and ordinance testing and investigations.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the proposed technologies to support BMDS design and analysis activities, battlefield munitions, safety, hypervelocity impact of space vehicles by man-made debris or micrometeroids, federal investigations of explosives and other energetics, and possible mining operations.

REFERENCES: 1. J. Glassman, “Combustion” 2nd edition, Academic Press, 1987.

2. R. Lloyd “Physics of Direct Hit and near miss warhead technology” Progress in Astronautics and Aeronautics, Volume 194, 2001.

KEYWORDS: Interceptor, Hit-to-Kill, Lethality, Hypervelocity, Hydrocodes, Shock-to-Detonation, Deflagration-to-Detonation, Algorithm, Explosives

MDA07-021 TITLE: Maneuvering Target Phenomenology

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: AB, GM, KI, SS, MK, SN, DEE

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Propulsion systems may perform a variety of maneuvers during the ascent phase of flight that can impact the performance of an interceptor or other parts of an MDA system. The maneuvers are generated by a variety of propulsion systems of both low (<1000lbf) and high (>1000lbf) thrust. Each propulsion-generated maneuver will generate a signature that may be exploited by an MDA system. The objective of this effort is to develop an accurate time-dependent capability to predict signatures from propulsion-generated maneuvers that can provide risk mitigation strategies for MDA systems.

DESCRIPTION: Maneuver examples include flying at angle-of-attack (thrust vector not aligned with the threat velocity vector) using single-nozzle or multiple-nozzle gimballing, staging motor retro-firing, etc. Maneuver propulsion systems operate in both pulsed and continuous modes for periods of time that range from less than a second to tens of seconds. Both startup and shutdown sequences can impact the MDA system and need to be addressed in addition to the phenomena during the steady burn operation. Over the past several years, new plume signature modeling has been focusing on propulsion systems with larger thrusts (>30,000 lbf) in a continuous mode of operation. This effort is focused on resolving the complex phenomena underlying lower thrust (<1000lbf) propulsion systems as well as the large thrust propulsion systems including their plume/plume interactions when required. Specifically, this innovative research effort will account for systems using novel propellant systems such as inert gases, with complex combustion chamber/nozzle geometries and time-dependent mass flow rates. As one example, an open cycle upper stage propulsion system has a gas generator exhaust with species and temperatures that are quite different from a main engine exhaust. The gas generator exhaust may be used for roll control (as in the TITAN upper stage) or some other function. The exhaust from the gas generator will interact with the main engine exhaust as well as vernier engine exhausts, if present. Since these propulsion systems are commonly used in high altitude environments, the emissions from the exhaust products colliding with atmospheric species are non-equilibrium and therefore require accurate collision cross sections that predict the excitation, dissociation and quenching of the radiating species across all spectral regimes. All of these phenomenology components, as well as others, must be accounted for to properly model the signature emissions from these low thrust systems. The physics and chemistry required to understand these phenomena must be developed into modules/models to accurately predict these critical features to provide risk reduction for current and future algorithm and sensor development.

PHASE I: For one maneuvering system at high altitude, identify the chemical and physical phenomena that is required to model and properly account for the complete process from propellant combustion through plume signature emissions. After all numerical, chemical and physical phenomena are identified; at a minimum, prioritize the importance of each component as a function of altitude, velocity, and spectral band. Finally, select one important complex component and demonstrate a theoretical or experimental innovative methodology to solve that component unknown. Proposed existing tools must clearly demonstrate they can already model complex, chemically reacting, two-phase flow propulsion systems and have the framework in place to account for three dimensional effects.

PHASE II: Identify all phenomenology signature processes that are required to model the low and high thrust propellant system. Demonstrate that the new or updated code/modules can predict the most dominant chemical and physical processes using advanced numerical solvers. Deliver the documentation, software and validation/demonstrations. Further, maximum practical use of existing plume software is desired to reduce both development and validation costs.

PHASE III: Transition advanced methodology into existing signature models used to support MDA elements. Apply software to a variety of missile interceptor systems as well as other problems of interest to MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial satellite companies require advanced software to predict contamination effects due to plume effluents.

REFERENCES: 1. Simmons, F.S. Rocket Exhaust Plume Phenomenology, AIAA, Reston, VA, 2000

2. G. Sutton, and Oscar Biblarz, Rocket Propulsion Elements, Seventh Edition, Wiley Interscience, 2001.

3. M. Braunstein and J. A. Cline, “Progress on Parallelizing a General Purpose Direct Simulation Monte Carlo (DSMC) Code for High Performance Computing Applications” AMOS 2003 TECHNICAL CONFERENCE, 10 September, 2003

4. N. Sinha, et al. "Applications of an Implicit, Upwind NS Code, CRAFT, to Steady/Unsteady Reacting, Multi-Phase Jet/Plume Flowfields," AIAA Paper 92-0837, AIAA 30th Aerospace Sciences Meeting, Reno, NV, 6 – 9 Jan 1992.

5. J. Cline, et al. “Parallel Performance of SOCRATES-P: The AFRL Direct Simulation Monte Carlo Flow Field, Chemistry and Radiation Code”, HPCMP Users Group Conference Proceedings, Nashville, TN, June 2005.

6. M. Braunstein, et al. “Quantum and classical studies of the O + H2 ® OH + H reaction using benchmark potential energy surfaces”, Journal of Chemical Physics, Vol. 120, p. 4316 (2004).

7. N. Gimelshein, et al. “Numerical prediction of UV radiation from two-phase plumes at high altitudes”, AIAA Paper 2007-0114, AIAA 45th Aerospace Sciences Meeting and Exhibit, Reno, NV, 8 – 11 Jan 2007.

KEYWORDS: nozzles; exit plane; rocket performance; two-phase flow, reacting flow; plumes, boost phase signatures, plume contamination, attitude control thrusters

MDA07-022 TITLE: <u>Advanced Missile Materials and Process Technologies</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: AB, AL, GM, KI, DEP, TH, MK, PAC-3

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Enhance the performance and/or producibility of missile body structures, components and thermal protection systems for implementation into ballistic missile defense (BMD) systems through development or utilization of novel materials and processes. Provide materials solutions to reduce procurement cost, lower life cycle cost, lower operational maintenance, reduce lead time, enhance mission reliability and improve manufacturability for low-rate, non-labor intensive production of (BMD) systems.

DESCRIPTION: MDA is seeking high-performance materials and process technologies for enhancement of current and block upgraded missile defense systems. These endo-atmospheric or exo-atmospheric intercept systems are highly complex missile systems. Novel materials and process technologies offer a significant potential for enhancing performance properties while improving producibility of these structures. Process technologies should be appropriate for modest production volumes; incorporate modularity, flexibility, simplified and/or low cost tooling; and be consistent with Lean and Six Sigma methodologies. The focus of this topic is for missile body and kill vehicle structures or components, excluding electro-optics and propulsion systems.

Technical areas of interest include, but are not limited to:

Kill Vehicles: The development of components that optimize composite performance to achieve material properties approximating or exceeding those of beryllium while maintaining or enhancing producibility, reliability, cost effectiveness, and volume/mass efficiency. Advanced hybrid composites could serve as replacements for beryllium components if their properties are optimized. In addition, such composites could be tailored for various other missile component applications including high thermal conductivity electronic packaging, electromagnetic interference shielding materials, and coatings or components to improve radiation hardening. The potentially superior properties of these composite components may also lead to improved nuclear survivability and functioning after prolonged periods in battlefield/storage environments by reducing shock, vibrations, and thermal stresses. In addition, such composites should provide improved heat dissipation (target > 1000 W/MK) and electromagnetic interference shielding for missile (Exo-atmospheric Kill Vehicle, Multiple Kill Vehicle, and Kinetic Energy Interceptor) electronics.

Aerostructures: Advanced missile defense interceptors require lightweight thermal protection systems (TPS) and aerostructures designed to minimize internal temperature rise and ensure missile airframe structural integrity during flight, including operation in adverse weather. These systems must meet a variety of requirements such as weight, erosion/ablation performance, cost, non-ionizing chemistry, and component survivability. New advanced interceptors are expected to achieve much higher velocities and longer flight times resulting in more severe aerothermal heating and loads than current systems. Aeroheating environments vary throughout the structure, but cold wall heating rates of 50-400 Btu/ft2-s and shear rates of 10-50 psf can be used for preliminarily material suitability analysis. Weather resistance requirements include impact due to rain, ice, snow, and/or sand. Proposals are sought that develop lightweight integrated heat shield and airframe designs which enhance the current TPS designs and improve insulative performance of the TPS, lightning strike performance and rain erosion performance.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle and to improve producibility, increase performance, improve thermal protection, lower cost, or increase reliability. Explore the concept and develop novel material or process for fabrication of a selected missile component. Produce test coupons of the material and measure relevant properties. Assess the fabrication cost, and impacts on service methods, safety, reliability and efficiency. Perform a preliminary manufacturability analysis and cost benefit analysis of deployment showing that the structure can be produced in reasonable quantities and at reasonable cost/yields, based on quantifiable benefits, by employing techniques suitable for scale up.

PHASE II: Based on the results and findings of phase I, demonstrate the technology by fabricating, and testing a prototype on a representative missile structure. Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles Demonstrate the system's viability and superiority under a wide variety of conditions typical of both normal and extreme operating conditions. Demonstrate scalable manufacturing technology during production of the test articles. Identify and assess commercial applications of the material or process technology.

PHASE III: Demonstrate new open/modular, non-proprietary composite materials and/or structures technology. Provide a potentially qualifiable design for an innovative structure that will provide for state-of-the-art advancement in aerospace and missile structural performance, safety, life extension, preventative and other maintenance. Demonstrate commercial scalability of the manufacturing process and the implementation of the software-based design tools for the commercial development and deployment of advanced structures. Commercialize the technology for both military and civilian applications. Demonstration should be in a real system or operation in a system level test-bed.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology should benefit commercial and defense manufacturing through cost reduction, improved reliability, or enhanced producibility and performance.

REFERENCES: 1. Reynolds, R.A., Nourse, R.N and Russell, G.W. “Aerothermal Ablation Behavior of Selected Candidate External Insulation Materials,” 28th AIAA Joint Propulsion Conference and Exhibit, July 1992.

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3. Reynolds, R.A., Nourse, R.N, and Russell, G.W. “Aerothermal Ablation Behavior of Selected Candidate External Insulation Materials,” 28th AIAA Joint Propulsion Conference and Exhibit, July 1992.

4. Russell, G.W. “Kinetic Decomposition and Thermal Modeling of Chartek 59C,” 29th AIAA Joint Propulsion Conference and Exhibit, June 1993.

5. Russell, G.W. “DoD High Speed Aerothermal Analysis and Design - Historical Review and New State of the Art Approaches,” NASA Thermal and Fluids Analysis Workshop, NASA Langley Research Center, Hampton, VA, August 2003.

6. Lindsay, J. and O’Hanlon, M.E. Defending America: The Case for Limited National Missile Defense, Brookings Institute Press, April 2001.

KEYWORDS: Missiles; Thermal Control; Thermal Insulation; Lightweight; Shock Resistance; Vibration Resistance; Rain Erosion; Hybrid Composite; Beryllium Replacement, Lightning Strike; Advanced Materials; Reliability; Producibility; Manufacturability

MDA07-023 TITLE: <u>Ballistic Missile Defense System Innovative Power Generation and Storage Devices</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: GM, KI, DEP, TH, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: MDA is seeking to improve the quality, reliability and producibility of batteries and related power sources, including concentrator solar arrays, through innovative ideas applied in creative ways to accommodate unique MDA system, subsystem and component requirements. These include developing new technologies, improving existing technologies, new applications of existing technologies, and inventive uses of commercial off-the-shelf and military off-the shelf technologies. Please note that some technology encompassed by this topic may be restricted under the International Traffic in Arms Regulations (ITAR, CFR 22, Part 121), which controls the export and import of defense-related material and services. If applicable, Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish.

DESCRIPTION: Many battery and power source products made for missile defense applications are manufactured in very low volumes. Enhancements are sometimes transitioned from the laboratory to the factory without a complete understanding of producibility constraints. Therefore, MDA is interested in innovative product enhancements that improve consistency and manufacturability while incorporating evolving technologies for integration into MDA systems. Intended enhancements range from improvements in fabrication of advanced materials to innovative components and processes that improve the capability of current systems. The goal is to enhance producibility of power sources as used in missile defense products, reduce unit cost and improve product reliability and performance to support future capabilities. For this solicitation, areas of interest include (but are not limited to) the following:

Improved Manufacturing & Production: Main interest areas include improving processing techniques to lower power source production costs and enhance performance (e.g. apply modern production technology to heritage processes), eliminating or modifying process steps that induce undesirable characteristics, and innovative software-based tools (e.g. CAM/CAD) to aid manufacturers with battery design and production monitoring. Other interest areas include innovations that reduce nonrecurring engineering costs, shorten lead times, and produce lighter, safer, and less expensive cells and batteries. Improvements that enhance production yield, consistency, reliability, producibility and manufacturability are desirable necessities for overall mission success.

Primary Reserve Batteries for Missile Applications: Two main interest areas are new and improved reserve battery manufacturing techniques; innovations that result in batteries with higher energy and/or power density (e.g. average specific power of greater than 3 kW/kg, specific energy greater than 200 Whr/kg at the battery level). Other desired improvements include models and simulations of activation dynamic conditions in reserve batteries, enhancing conformability to allow fitting batteries into unconventional shapes for efficient space utilization (e.g. shapes other than right cylindrical or rectangular solids), improving battery safety under normal and abnormal use conditions (e.g. fire exposure); reducing “touch labor” during fabrication, improving subcomponents used in these batteries (e.g. high efficiency insulations, advanced materials for use in thermal batteries), reducing parts count and simplifying fabrication techniques to reduce cost and complexity (e.g. easier to assemble battery subcomponents).

Aerospace-grade Secondary Lithium Batteries: Two main interest areas for rechargeable lithium batteries are improved manufacturing techniques and developing reliable, lower cost processes for optimal cell designs with resulting battery configurations that can accommodate long duration space missions (e.g. low earth orbit, medium earth orbits for up to ten years calendar life). These interest areas include achieving long-term available and consistent materials as used in rechargeable lithium cell production, beneficial variations to space-quality lithium rechargeable cells that enable them to achieve moderate to high charge and discharge rates with suitable voltage characteristics (e.g. discharge at 10C rates), improved calendar life; increased cycle life at greater depths of discharge (e.g. over 20,000 cycles at >50% depth of discharge); improved charging and cell balancing methods; software models that allow cell and battery life-cycle simulation (voltage decay, capacity fade, response to limited over charging, thermal exposure, etc.) to help achieve confidence in cell and battery designs, and improving cell safety (e.g. benign response to abusive conditions like over charging, over discharging).

Space-qualifiable Radiation Hardened Solar Arrays: Current generation of solar arrays for power generation in space are susceptible to degradation in high radiation and thermal environments. Addition of thicker cover glass to minimize these effects substantially adds weight to the array. Concentrator solar arrays can minimize this weight penalty while increasing performance. Innovations that harden multi-junction photovoltaic cells against radiation and thermal effects are also focus areas. Manufacturing and producibility are key requirements since historically, solar array failures account for almost 40% of all spacecraft failures.

PHASE I: Develop conceptual framework for battery or battery production process design/design modification, hardenable solar array and manufacturing processes, for integration into MDA systems or subsystems to increase performance, lower cost and increase reliability and producibility. Where possible, limited scale demonstrations should be provided to assist in the judging of merit of the new technology.

PHASE II: Validate the feasibility of the power generation and storage device or manufacturing process technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation by demonstration should sufficiently show near term application to one or more MDA-interest systems. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable. The possibility of commercial benefit or application opportunities for the innovation is desirable.

PHASE III: The intention is to successfully implement the new power storage technology for use by MDA and other customers as appropriate. Implementation would include, but not be limited to, demonstration in a real system or operation in a system level test bed, and flight testing of the battery or solar array concepts. The new power source technology should be implemented at a manufacturer and be ready for inclusion in MDA applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: MDA uses different types of power storage devices. Thermal primary batteries are used in military and commercial launch vehicles to power various subsystems in-flight. Lithium oxyhalide (active type) batteries are also used for some commercial applications and may be capable of replacing other battery types (e.g. where weight is a factor). Rechargeable batteries are used in aerospace applications for on-board power and are also widely used in commercial applications, as are space-qualified solar arrays. Finally, the manufacturing and producibility enhancements for MDA batteries could be applicable to commercial battery manufacturing lines.

REFERENCES: 1. http://www.acq.osd.mil/mda/mdalink/html/mdalink.html provides an overview of MDA platforms.

2. http://www.eaglepicher.com/EaglePicherInternet/Technologies/Power_Group/Defense_Applications, Products_Services provides documents describing MDA-interest batteries and related technology.

3. http://www.lithion.com/lithion/index.html provides links to various documents describing MDA interest rechargeable lithium battery technology.

4. http://www.sandia.gov/news-center/resources/tech-library/index.html provides links to documents (some detailed) describing various MDA-interest battery technologies.

5. http://www.electrochem.org provides detailed information on current state-of-the-art advances and research, mainly for MDA-interest rechargeable batteries.

6. Handbook of Batteries, 3rd Edition, McGraw-Hill, provides detailed information regarding the design and construction of thermal, liquid reserve and rechargeable batteries.

7. van Schalkwijk and Scrosati, Advances in Lithium-Ion Batteries, Kluwer Academic / Plenum Publishers, 2002.

8. http://wwwspectrolab.com

9. http://www.emcore.com/procuct/photovoltaic.php for high efficiency, multijunction solar cells for space applications.

KEYWORDS: power density, energy density, conformability, battery, lithium, rechargeable, space, solar, photovoltaic

MDA07-024 TITLE: Improved Manufacturing Processes for Propulsion Technology

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: GM, KI, DEP, TH, MK

OBJECTIVE: The Manufacturing and Producibility (DEP) Directorate of the Missile Defense Agency (MDA) is seeking manufacturability and cost reduction improvements for low-cost, high-performance materials and components. The requirements for reliable performance in both lower and upper boost phases, as well as end game, require innovative and mature manufacturing processes. Applications of interest include solid boost motors as well as solid and liquid divert and attitude control systems (DACS).

DESCRIPTION: MDA propulsion systems exhibit stringent performance requirements while simultaneously exposing materials to severe operating conditions. Existing nozzle materials, such as phenolic-based ablators, high temperature metals, and carbon-carbon composites exhibit unacceptable erosion. Most metals and ceramic matrix composites provide inadequate thermomechanical properties at temperatures above 3000°F. Existing insulation materials, such as ethylene propylene diene monomer (EPDM) rubber, exhibit excessive charring which produces particulates and gas species that contaminate the exhaust plume. Composite materials that have acceptable performance often employ extremely costly fabrication techniques. High performance propulsion materials often utilize manufacturing processes which are not sufficiently mature, resulting in unacceptable property variability. Additionally, there is a need to characterize combustion roughness and instability in liquid DACS.

• High temperature ablation-resistant structural materials: Ablation-resistant materials such as ceramics, composites, and refractory metals for components such as liners, nozzles, and hot gas paths. DACS materials including Zr- or Hf-based composites shall be subjected to pressures above 2000 psi and flame temperatures greater than 4000°F. Aluminized motor materials (TaC-based) must operate at 2000 psi and at flame temperatures greater than 6000°F. The materials must be able to tolerate large temperature gradients such as those experienced at motor initiation. A typical minimum
property is a tensile strength of over 50 ksi (345 MPa).

• Structural insulative materials: DACS components are attached to missile structures and electronic components that cannot tolerate high temperatures. Structural insulators including Na-Zr-P type ceramics, low conductivity/high strength foams, and ZrO2-based composites are desired. Optimal structural insulators will be dimensionally stable to high temperatures, will not pyrolyze, and will exhibit nominal 15 ksi (34.5 Mpa) strength. Structural insulators will have high fracture toughness and thermal stress resistance, and exhibit low thermal diffusivity. Materials are desired for use at 3000°F with a future
temperature goal exceeding 4000°F.

• Liquid Propellants: Develop and carry out quick and inexpensive propellant testing methods to identify and solve combustion roughness problems and combustion instability.

PHASE I: Develop a strategy to demonstrate the producibility of the proposed propulsion product including integration with an MDA system. The goal of the Phase I effort will be to increase performance, lower cost, and/or increase reliability of the selected component. The proposal should provide a quantifiable assessment of the feasibility and pay-off of the selected technology. Experimental data to support the Phase I feasibility is desired but not mandatory.

PHASE II: Implement the manufacturing plan and quantify key milestones. Validate the feasibility of the material or component by demonstrating its use in the operation of manufactured items for MDA systems, subsystems, or components (such demonstration assumes adequate material and component characterization). A partnership with a potential supplier of MDA systems, subsystems, or components is highly desirable. Identify commercial applications of the technology and other DoD opportunities that benefit from the innovation.

PHASE III: Complete technology transition via successful demonstration of a new product technology. This demonstration should show near-term application to one or more MDA element systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Manufacturing improvements in materials have direct applicability to space launch vehicles, gas turbines, and automotive technologies. Actuator technologies have wide applicability to the aerospace industry to include both aircraft and rocket technologies. Because of the wide variety of chemicals and materials involved, it is anticipated that the private sector will benefit from test procedures for aging propellants.

REFERENCES: 1. George T. Sutton, “Rocket Propulsion Elements; Introduction to the Engineering of Rockets” Seventh Edition, John Willey and Sons, 2001.

2. Missile Defense Agency Link: http://www.acq.osd.mil/mda/mdalink/html/mdalink.html

3. Ballistic Missile Defense Basics: http://www.acq.osd.mil/mda/mdalink/html/basics.html

KEYWORDS: Composites, Divert and Attitude Control System, High Temperature Material, Insulation, Non-Destructive Testing, Propellants, Rocket Motor

MDA07-025 TITLE: Innovative Manufacturing Technologies for Low Cost, High Reliability Electronic Packaging

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: AB, AL, BC, GM, KI, DEP, TH, SS, MK, SN, PAC-3

OBJECTIVE: Develop and demonstrate innovative manufacturing technologies, test/inspection procedures, accelerated test methods and/or software tools to mitigate program risk relative to the insertion of low-cost electronic packaging technologies into high performance and high reliability MDA/military systems. The developed manufacturing technologies/procedures/methods shall be demonstrated on an identified MDA/military system technology insertion. Metrics for the assessment technology being developed will be; assessment time duration cost of assessment and accuracy of long term reliability prediction.

DESCRIPTION: MDA/military system reliability is more important than ever. Acquisition programs must deal with lower budgets, shorter insertion schedules and higher system costs as well as being faced with the insertion of a plethora of new technologies and materials. Similarly, deployed hardware life is similarly being stretched beyond planned dates. In order for systems to meet performance goals and cost limits, fielding of lower cost passivation packaged electronics must be utilized. These new packaging technologies have applicability in commercial markets, have lower cost and utilize commercial manufacturing developing higher quality processes. MDA/military programs need to assure that these technologies will function throughout the lifecycle of military systems.

New packaging approaches, which sometimes are referred to as non-hermetic packaging, have processes and data to support commercial product performance and lifecycles. In order to utilize these materials/manufacturing technologies reliably for interceptor control electronics as well as in TR modules for high power radars the long term reliability of these technologies in their anticipated service environment must be established. Existing test methods are typically called out for contractual acceptance and rejection criteria, but these test methods were established to test more traditional hermetic packaging technologies to accelerate their particular failure mechanisms. The embedded and passivated packaging technologies utilized in low cost packaging have unique construction/materials which require specific testing and modeling to assess how they will perform during and after a lifetime of operational and environmental stresses. Current and future military spending limits will make the establishment of unique testing protocols for each new technology to be inserted into a system cost prohibitive. Test and inspection criteria that assure long term reliability for low cost packaging technologies are critical for fielding higher performance interceptor control electronics, high power solid state radar arrays and power modules. This topic seeks proposals that utilize innovative manufacturing processes, inspection and reliability assessment technologies. The technologies being developed will be evaluated and validated on microelectronics transitioning into MDA/military application systems and involve technical R&D risk.

PHASE I: Formulate and demonstrate a reliability assessment technology capable of accurately predicating long term life for a component, line replaceable unit that utilizes a low cost microelectronics non-hermetic packaging technology. Identify the processing techniques, materials and manufacturing processes of the microelectronics component/assembly to be evaluated with the developed technology and associated reliability test plan. Establish the basic feasibility of the proposed technology to accurately predict long term failure mechanisms for the assembly and application system chosen.

PHASE II: Produce, demonstrate and test statistically significant quantities of a system design specific component/line replaceable module hardware using the developed tools, procedures, technologies to validate performance and the ability of the developed technology to accurately predict system level life times.

PHASE III: Establish industry standards for life prediction tools and utilize developed technologies and procedures to predict long term life and associated logistical support requirements for MDA/military technology insertion.

PRIVATE SECTOR USE OF TECHNOLOGY: Private sector applications include cell phones, personal communicators, computers, radar systems, automotive control electronics etc.

REFERENCES: 1. WASPP Program: Advanced Passivation for Advanced Packages and Harsh Environments, Reusnow, C.; Wheelock, S., Advanced Packaging Materials: Processes, Properties and Interfaces, 2001. Proceedings. International Symposium on Volume , Issue , 2001 Page(s):63 –67

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KEYWORDS: Electronics Packaging, Electronics Miniaturization, Low Cost Radar T/R Modules, Reliability

MDA07-026 TITLE: Manufacturing Technology Innovations for Advanced Electro Optical Components/Systems for Missile Defense Applications

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: AB, GM, DEP, TH, SS, MK

OBJECTIVE: Identify and develop innovative manufacturing, packaging, integration, and processing technology for developing robust and reliable seeker/sensor components and electro-optical devices for missile defense applications.

DESCRIPTION: MDA is seeking innovative technologies to develop materials, components, and interfaces that can be inserted into sensors, seekers, or other electro-optical systems of missile interceptor kill vehicles and/or satellites. Effort is to improve the performance of seeker and electro-optical units such as long wave infrared sensor systems, cold shield housing and components, space laser systems and ease of integration and calibration at lower cost. Innovations are sought in:
(1) Materials processing, manufacturing, packaging, or integration of components used for cold shield, thermal vacuum housing, sensor cryogenic interface, integrated dewar assembly, transmission windows and anti-reflective coating in missile interceptor or satellite seeker units. Developed products or techniques should also help in aiding the integration and alignment of seeker components while lowering the cost.
(2) Design, packaging, and integration techniques for producing fiber coupled laser diode modules that have high optical coupling efficiency. Developed products or techniques should be contamination free and robust against harsh thermal, mechanical, and vibration environments for high power laser systems for missile interceptor and satellite payload applications.
(3) Material processing and manufacturing of highly thermally conductive materials such as copper diamond, silver diamond or other advanced materials that can be used in high power diode laser manufacturing or other optoelectronics and electronics applications with CTE matching to the host device materials such as GaAs or other III-V semiconductors. Developed materials should have high surface, edge, and internal morphological quality.

Proposals can be submitted to address either one or combinations of the above materials or techniques.

PHASE I: Develop conceptual technology for electro-optical component product design, manufacturing, integration approach and test method that will improve performance, lower cost, or increase reliability of optical devices, components, and systems described above for BMDS applications. Offerors are encouraged to work with system (interceptor or satellite) and/or their respective payload contractors to help ensure applicability of proposed effort and to facilitate future technology transition.

PHASE II: Validate the feasibility of electro-optical product technologies described above by manufacturing, packaging, validation by testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with system and payload contractors. A partnership with a current or potential supplier of MDA element systems, subsystems or components is highly desirable.

PHASE III: In this phase, the contractor will apply the innovation demonstrated in the first two phases to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations developed under this topic will benefit both DoD and commercial space and terrestrial programs. Additional applications of this technology may arise in manufacturing of semiconductor opto-electronics, IR sensors, cryocooler and cold shield housing, lasers, optical materials, scientific instrumentation, astronomy, and medical fields.

REFERENCES: 1. Dereniak, E. L. Boreman, G. D., Infrared Detectors and Systems, John Wiley & Sons, Inc., 1996.

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KEYWORDS: integrated dewar assemblies, thermal vacuum housing, cryogenic operation, cold mass, cold shield, transmission windows, fiber coupling, diode lasers, high thermal conductivity materials.

MDA07-027 TITLE: Mitigating Lead-Free Issues in Electronic Circuit Board Manufacturing and Repair

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: AB, AL, BC, GM, KI, DEP, TH, SS, MK, SN, PAC-3

OBJECTIVE: The Missile Defense Agency (MDA) and other military services are seeking to mitigate issues in electronic circuit board manufacturing and repair related to lead-free solders and surface finishes. (1) New and reliable processes are needed for soldering lead-free Ball Grid Array (BGA) electronic components on circuit boards manufactured with tin-lead solder and subsequent reworking circuit boards with BGAs. The processes would address both the rework of the circuit board as well as rework of the BGA solder interconnects. (2) New conformal coating materials are needed to mitigate the risk of tin whisker caused short circuits on electronic assemblies. These coating materials need to provide a high degree of reliability in weapon system applications and be compatible with existing weapon system manufacturing processes.

DESCRIPTION: In the last three years, the European market driven movement to use lead-free surface finishes on electronic components has eliminated about 75% of the supply chain availability of electronic components suitable for military electronics. While much of the commercial electronics industry is shifting to the use of lead-free solders and finishes for circuit boards and components, the defense industry is reacting by adapting its circuit board technologies to meet its contractual reliability and service life requirements. Generally, the assembly and rework processes involving lead-free solders and surface finishes and combinations with tin-lead solder are immature.

One of the threats to military electronic system reliability is solder joint failure caused by copper dissolution during repair and rework cycles. During rework and repair of printed circuit boards, when making a solder joint whether lead (Pb) free or tin-lead, there is a certain amount of dissolution of the copper circuitry (pad) that takes place. In the past, this has not been a significant problem because circuit traces and soldering pads were thicker. However, today much less copper is being used in circuit pads and traces. In many cases the amount of copper dissolution due to rework or repair of component interconnects significantly reduces the reliability of the circuit. This is especially true with the removal and replacement of Ball Grid Arrays (BGAs) and other fine pitch devices such as the new Quad Flat No-Lead packages. The reduction of z-axis copper thickness due to copper dissolution leads to a thinner than normal copper pad interface and a reduction in the mechanical strength of the component interconnection. Since the solubility of the copper into solder increases with an increase in temperature, this problem is more pronounced in assemblies built with lead-free solder. Although most aerospace companies have no requirement to build military hardware with lead-free solder, they do use some COTS assemblies that may only be available with lead-free solder.

In circuit board rework or repair the entire solder joint is normally heated to a liquid state and intermetallic compounds are formed in part from the dissolution of the base material (copper). Test data indicates that the amount of intermetallic compound formed affects the strength of the interconnection; too much makes the connection brittle and too little makes the connection weak. The correlation of time and heat (reheat due to repair) needs to be determined through test protocols and evaluations to learn the amount of thermal cycles or repair cycles to which a copper pad can be subjected. Questions that need to be answered include “How much heat can be applied and for how long before the circuit is at risk of being totally unreliable?” and “How many times can this reheat / rework be performed prior to the loss of the circuitry or to the point that the interconnect becomes un-reliable?” Copper dissolution as related to different solder compositions and component sets and printed circuit board copper pad thickness are essential variables that need to be studied and correlated. Similarly, copper pad thickness remaining after repair work and the thickness of the intermetallic structure are key elements in determining what is an acceptably strong and reliable interconnect. Testing of solder joints with various copper pad thicknesses and rework cycles is essential to answering questions of reliability as they relate to copper dissolution from the circuit board copper pads. Design of experiments using both “Lead-free” and “Leaded” solder alloys, and representative types of solder interconnections should be conducted with various heating methods such as reflow ovens, rework systems, and solder irons to determine amounts of heat and time for heating. Measurements should be made on resulting intermetallic compound thickness and copper dissolution rate. Flux, surface wetting, joint compounds, and quality all need to be considered in the evaluation.

A second threat to military electronic systems is failures caused by tin whisker short circuits. A large number of defense programs have experienced tin whisker problems, which has increased significantly by the move to replace legacy tin-lead (SnPb) surface finish on electronic components and assemblies with a pure tin (Sn) surface finish. Over time, a pure tin surface finish can grow conductive tin whiskers that often cause short circuits in electronic assemblies. There are two approaches currently favored by aerospace manufacturing to mitigate the risk from tin whiskers. However, both have limitations and do not adequately address the problem. They are:

1) Replace the pure tin surface finishes with tin-lead surface finishes. Although this will reduce the size of tin whiskers and significantly reduce the risk to the electronics industry, these processes cannot be applied to some assemblies because they do not comply with environmental requirements.
2) Use a pure tin surface when there is no other option and then apply a conformal coating over the pure tin surfaces to captivate tin whisker growth. Unfortunately, years of testing by the aerospace community have proven that tin whiskers can penetrate existing conformal coating materials.

Aerospace manufacturing does not currently have a minimum set of solutions required to mitigate tin whisker risk over the services life of many military programs. Development of a new conformal coating that successfully prevents tin whisker penetration would solve that problem. Additionally, the new conformal coating would be quite attractive to many defense programs that already use conformal coatings for reasons other than tin whisker risk mitigation. A new coating that addresses multiple needs would be a producibility enhancement.

The new conformal coating must be useable in weapon systems with proven production processes, and applicable for deployment in harsh military conditions. It must also perform over a long service life. Based on current coating use, there may be two classes of coatings that need development. One would meet the requirements for weapons systems that are not exposed to a JP-10 fuel environment.  The second would be designed to operate without swelling in the JP-10 fuel storage environment common in cruise missiles.  A single conformal coating is desirable.

The desired conformal coating would apply to electronic circuit boards and assemblies containing some electronic components with a pure tin surface finish on the interconnections.  This coating could contain tin whisker growth by not allowing tin whiskers to crack, tear, or puncture the coating and by trapping the whiskers under the surface of the coating.  The coating should be durable, in that it would not crack due to age and cumulative fatigue over the service life of weapon systems deployed in military environments.  The new coating processes should be applied without pinholes, be repairable, and removable.  Its properties should include minimal thinning over sharp edges, such as those encountered on microcircuit leads.  The coating should be uniformly applied over fragile electronic devices without breaking them as the coating cures.  The coating should also maintain structural integrity during thermal cycling and have Thermal Coefficient of Expansion (TCE) values compatible with electronic circuits so that TCE forces will not harm electronic components.

The TRL / MRL entry level for this project should be Level 4, while the exit level should be Level 6.

PHASE I:  Develop and demonstrate the feasibility of evaluating processes to address the specific needs identified in this topic.  Conduct experimental and analytical efforts as necessary to demonstrate proof-of-principle.

Determine the dissolution rate of the copper circuit pads with various selected solder alloys using various heat sources, fluxes, and printed circuit board copper circuit pad thicknesses by component packaging style and type.  Quantify the number of rework cycles by copper thicknesses and correlate this to component types for standardization and guidance for DoD hardware.  Create a Guidance Matrix by component style and type in correlation to circuit trace and pad copper weights.

Define key performance parameters for coating material characteristics required to contain tin whisker growth.  Perform initial formulation and testing of new coating materials, with the goal that some of these materials will demonstrate significant improvement in the key performance characteristics, compared to existing commercial coatings.  This effort may include development of applicable test technology, as required for the demonstration.

Develop a well-defined Phase II development and demonstration plan.  Concepts may involve research and development, modeling, material characterization, technology development, tooling, test and validation techniques, and process controls.  It should include a metric for measuring success, expected technology objectives for each year, and a methodology for managing the project risk.

PHASE II:  Refine the technologies and processes developed in Phase I, per the Phase II plan.  Evaluate and demonstrate these technologies/processes in a laboratory and production environment to show the enhanced reliability resulting from its use.  Demonstrate producibility with selected military applications.  Develop an implementation / transition plan.  Conduct environmental durability testing and coating application producibility testing for tin whisker coating materials,

PHASE III DUAL USE APPLICATIONS:  Demonstrate the new process technology as part of an existing military program, in particular one that is flowing down required processes to subcontractors.  Transition the new coating material into production.  Provide a national communication effort to military programs to create product awareness and subsequent market demand.  Applications of these technologies and processes will apply to many if not most of the MDA, Army, Navy, and Air Force defense systems affected by the move to lead-free solders and surface finishes.  Additional applications to NASA programs are to be expected.

PRIVATE SECTOR COMMERCIAL POTENTIAL:  The applicable sector of commercial electronics that would find these new technologies and processes useful would be for products with high reliability and long service life requirements.  This would include medical applications, nuclear power plants, commercial aviation, space based systems, and certain communication applications.

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4. “Program Management Systems Engineering Management Guidelines for Managing the Transition to Lead-free Electronics:  GEIA document number GEIA-HB-0005-1  http://www.geia.org/

5. “Performance Standard for Aerospace and Military Systems Containing Lead-free Solder”;  GEIA document number GEIA-STD-0005-1  http://www.geia.org/

6. “Standard for Mitigating the Effects of Tin in High-Reliability Electronic Systems:  GEIA document number GEIA-STD-0005-2  http://www.geia.org/

KEYWORDS: Lead-free, Ball-Grid Array, Tin Whisker, Risk Mitigation, Conformal Coating

MDA07-028        TITLE: Production Enhancements for Integrated Anti-Tamper Technologies

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: AB, AL, BC, GM, KI, DEP, TH, SS, MK, SN, PAC-3

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE:  Develop and implement production enhancements for Anti-Tamper (AT) technology for the protection of critical technology against exploitation.

DESCRIPTION:  The MDA Director has issued a directive necessitating the protection of critical program information from unintentional transfer and the policy for the implementation of Anti-Tamper technology on MDA acquisition and associated technology programs.  AT technology consists of engineering activities that prevent and/or delay exploitation of critical technologies in U.S. weapons systems.  The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component.  This effort will focus on developing innovative AT techniques and technologies that provide protection from reverse engineering and compromise of both hardware and software.  Attention will be placed on integration into weapons platforms and their associated hardware and software.  As a result, the MDA will maintain a technological edge in support of the war fighters.

The intended research area is the development of improved manufacturing and production techniques for use when integrating Anti-Tamper into the weapons systems or component manufacturing process.  Such measures could reduce risk associated with current AT integration efforts and improve chances for successful integration of protective techniques/technologies. Though the particular solution may be tailored to an individual design or step in the manufacturing process, the concept and methodology of the solution may be applicable to the manufacture and production of protection for various COTS and military hardware.

The focus is to develop protection that 1) addresses a significant challenge associated with implementing AT utilizing current manufacturing and production processes, or 2) makes AT implementation a seamless part of the weapons system or component manufacturing process.  These production enhancements should reduce the time, technical risk, or cost associated with current methods of AT implementation.

PHASE I: The contractor shall develop the conceptual framework for new and innovative AT production enhancements. The contractor will also perform an analysis and limited bench level testing for an understanding of the production enhancements and provide metrics to be used to demonstrate the value of these enhancements.

PHASE II: Demonstrate and validate the use of AT production enhancements via one or more prototype efforts and estimate the effectiveness of the techniques. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Integrate selected AT production enhancements into a critical system technology, for a BMDS system level test-bed. This phase will demonstrate the application to one or more MDA element systems, subsystems, or components and the products utility against industrial espionage. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to protect against tampering in a real-world situation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve producibility or performance of products that utilize innovative process technology.

REFERENCES: 1. Wills, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.

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KEYWORDS: Anti-Tamper (AT), Electronics, Volume protection, Reverse Engineering, Exploit

MDA07-029 TITLE: <u>Sensor Data Fusion</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: DV, GM, TH, BC

OBJECTIVE: This topic seeks to apply innovative discrimination concepts to the fusion of sensor (feature) and contextual scenario information through the development of robust algorithms, software, and/or hardware necessary to collect, process, and automatically fuse information from multiple sources (radars either at the same or different frequencies as well as EO/IR sensor assets). This topic further seeks to enhance the representations of the attributes and capabilities of a sensor or sensor system in a manner that facilitates automated sensor fusion and exploitation of the sensor data from the wide range of sensor systems (radar/EO/IR) used by the Missile Defense Agency. Solutions must be capable of accurately and reliably supporting acquisition, track, discrimination, and engagement of threatening objects across a spectrum of threat classes and environments.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) performance is heavily dependent upon data from dispersed and disparate radars and other types of sensors. Timely and accurate fusion of data collected from a variety of radars and/or other sensors that acquire information from multiple perspectives and/or different frequencies can provide for a more accurate picture of the adversary threat cloud than any single radar or group of radars operating independently. The goal of the data fusion process is to operate on a combination of sensor measurements, features, track states, and object type and identification likelihoods to produce a highly accurate integrated picture of the battlespace. Innovative techniques applied to the BMDS realm which are grounded in advanced mathematical decision theory and/or probabilistic inference algorithms as well as software, and/or hardware that enable this synergistic fusion and interpretation of data from disparate BMDS radars and/or other sensors should enhance system acquisition, tracking and discrimination of threat objects in a cluttered environment and provide enhanced battlespace awareness. Fusion of data at several hierarchical levels may be required.

Technical issues that must be addressed include: sufficiently accounting for uncertainty in both threat genealogy and sensor feature measurements, over-reliance on a priori information, spatial and temporal registration of radars, data throughput within and between sensor platforms, processing speed and capacity, data latency and gap handling, target feature exploitation, and sensor calibration.

Sensor (EO/IR/radar) knowledge representation refers to the idea of encapsulating the combination of the data provided by a sensor or sensor system with its meaning as given by the knowledge the human end user possesses about the attributes and capabilities of the system into a single machine readable source. Oftentimes, human intervention is required to transform these bits of data into useful information about the cause of an anomalous event. Methods for including semantic information about the sensor within the sensor data will enable automated data fusion from multiple sensors into cohesive usable information on detected events are of interest. This effort includes research in the sensor domain and its application in automated machine processing of sensor data but will not include new types of sensor hardware or modifications to existing hardware.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced sensor data fusion concepts/methods for the representation of sensor attributes and capabilities that are easily adaptable to a wide range of sensors using simulated sensor data.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic environment using data from multiple sensors (as applicable) assets sources. Demonstrate ability of technology to work in real-time in a high clutter environment.

PHASE III: Integrate technology into BMDS system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued as government applications of this technology will produce near term benefits from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control, weather radar applications areas of transportation and shipping, e-commerce and robotics industries.

REFERENCES: 1. R. Duda, P. Hart, and D. Stork, “Pattern Classification”, 2nd Ed., Wiley Interscience, November, 2000

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KEYWORDS: Inferencing Algorithms, Decision Theory, Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor, 3-D Imaging, Knowledge Representation, Machine-Processable Meaning

MDA07-030 TITLE: Mitigation of Radar Clutter Using Algorithmic Techniques

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: DV, GM, SN

OBJECTIVE: This topic seeks to develop innovative clutter suppression concepts and approaches which will enhance the ability of radar systems to perform detection, tracking, and discrimination in a cluttered environment. The proposed approach should allow robust mitigation of one or more types of the clutter that is anticipated in a strategic context. Purely algorithmic approaches are of primary interest, although it would be acceptable for an algorithm to be coupled with an incremental and low-cost modification to existing MDA radar assets.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) performance is heavily dependent upon data from dispersed and disparate radars and other sensors. Accurate radar data is needed no matter what the environment is like. We anticipate that the scene around a ballistic complex will include intentional and non-intentional (rain, electromagnetic interference, etc) clutter. This clutter background will decrease the ability of BMDS radars to detect, track, and discriminate objects of interest. Algorithms that mitigate the effect of these intentional and non-intentional clutter backgrounds while maintaining all required radar data on objects of interest are desired. A proposed algorithm may focus on only one type of clutter and may take advantage of the capabilities of any or all of the Missile Defense System's radars. Efficient, highly reliable algorithms will be required to maintain clutter suppression performance under a variety of intentional and non-intentional clutter environmental conditions. Proposed approaches that minimize radar resource utilization while providing maximum clutter suppression capability in an environment where one or more types of clutter are present and work in real time are required.

PHASE I: Develop proof of principle demonstrations for clutter suppression concepts using simulated data. Perform sufficient analysis and testing to ascertain the capabilities and performance of the approach to a first order. Recommend a plan for further development of the algorithm to optimize its functionality and allow it to run on a real-time system with a minimum allocation of compute assets.

PHASE II: Perform further development of the algorithm in order to enhance its functionality and run it against a wide variety of clutter cases using realistic environmental data, to include realistic processing speeds in complex scenarios.

PHASE III: Integrate the technology into the BMDS system in coordination with BMDS System Engineering and the Element Program Office. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATION: This product can be used to support clutter suppression in the aerospace sector, to include air traffic control, weather radars and aircraft collision avoidance. Automotive collision avoidance systems are another potentially compelling target for these algorithms.

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KEYWORDS: clutter, clutter suppression, countermeasure, counter-countermeasure, radar

MDA07-031 TITLE: Game Theory In Ballistic Missile Defense (BMD)

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: DV, BC

OBJECTIVE: This topic seeks to develop advanced, innovative models of the offense and defense in a ballistic missile defense engagement using game theory techniques that will provide appropriate testing scenarios for evaluation and optimization of sensor and weapon resource management algorithms.

DESCRIPTION: As the Ballistic Missile Defense System (BMDS) evolves to incorporate new and enhanced sensors and weapon systems to contend with increasingly complex ballistic missile threats, optimization of BMDS sensor and weapon resource management algorithms will require that the anticipated objectives and strategy of a potential adversary are accounted for. Game theory techniques can be applied to ballistic missile defense objectives at two levels. At the structural level, game theory approaches can be used to determine the quantities of BMDS sensors and weapons as well as the geographical locations of the fixed system assets. At the tactical level, game theory can be applied to determine the optimum use of available BMDS assets through appropriate sensor and weapon resource management. This topic focuses exclusively on the tactical application.

Proposals should develop a framework for modeling an intelligent offense thus providing a capability to define stressing engagement scenarios against which the defense's weapon and sensor resource management methodologies can be evaluated. The proposed methods should account for the following factors:

In planning an attack, a potential adversary with given inventory of missiles and weapons has essentially three decisions to make for each missile:

a. Relative launch timing: near simultaneous launches would provide stressing conditions for the defense's sensors while extending an attack over time can lead to exhaustion of the defense's weapon inventory without careful resource management.

b. Aimpoint Location: through the choice of target location the offense might expect to be able to exploit different kinematic engagement envelopes of different fixed weapon sites potentially leading to local exhaustion

c. Countermeasures: the offense has a choice of the type of countermeasures, if any, to deploy and the timing of such a deployment. Through variation of these parameters, the offense might hope to be able to affect the difficulty and approach to discrimination by the defense and the sensors resources required to effect it.

PHASE I: Develop a mathematical model of a BMD engagement that demonstrates the effects of changes to offense and defense options which account for the factors mentioned above. Using Game Theoretical approaches, establish techniques for computing optimum strategies for offense and defense using simulated data.

PHASE II: Develop and update the models in Phase 1 to include incomplete knowledge by each player of the other's capabilities and pay-off matrices. Integrate with simulation framework to allow the testing and evaluation of resource management algorithms in realistic, complex threat scenarios.

PHASE III: Integrate the technology into the BMDS system in coordination with the BMDS C2BMC Element Program Office. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATION: This technology is applicable to air traffic control, the transportation and shipping industry, e-commerce and robotics industry.

REFERENCES: 1. Global Ballistic Missile Defense: A Layered Integrated Defense. http://www.mda.mil/mdalink/pdf/bmdsbook.pdf

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KEYWORDS: Game Theory; sensor resource management; weapon resource management; countermeasures

MDA07-032 TITLE: <u>Advanced Passive and Active Sensor Technology for Discrimination</u>

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: DV, GM, TH, MK

OBJECTIVE: Research and develop innovative concepts which will significantly improve current performance of passive and active electro-optical and infrared sensors for use in future ballistic missile defense systems (BMDS) discrimination.

DESCRIPTION: Future ballistic missile defense face complex countermeasures, such as multiple targets mixed with decoys, balloons and can be cool shrouded. Key functions of a missile defense interceptor are to detect, track and discriminate threat objects. Discrimination relies on the use of sensors that perform a variety of remote measurements. Both active and passive sensors, and the combination of them are critical for future discrimination either in the seekers, or airborne and space borne platforms.

This topic solicits new ideas for passive and active sensors that will be able to detect, track, and discriminate complex targets at ranges beyond 1000 km. The topic emphasizes on innovative concepts, components and technologies for compact and light-weight IR sensors and ladar receivers. On-FPA and near-FPA data processing and data rate reduction capabilities are also sought for real time discrimination. Radiation hardened environment operation needs to be considered. Passive IR sensors require higher performance to include improved sensitivity, uniformity, operability, and resolution; reduced readout noise, advanced read out integrated circuits (ROIC) capabilities, cutoff wavelengths from 5 to 14 microns, large array sizes (in excess of 256 x256), and high operating temperatures (> 77K). These performance parameters should exceed those of current state of the art FPA detector technologies. Multi-color focal plane arrays (FPAs) should be designed to detect two to four wavebands. ROIC with sub-nanosecond response time and in an excess of 40M carrier charge capacity unit cell are of great interest. Hybrid receivers which are simultaneously capable of coherent and direct detection are also sought. Direct detection should meet or exceed Geiger response. Compact form factor should be capable of supporting receiver integration in a coherent or direct detection. Large format ladar receiver and /or APD arrays operating at 1064 nm are needed. Improvements to the receiver array can include demonstration of significantly reduced dark current, improved sensitivity from photon counting, with significant reductions in receiver size.

PHASE I: Research and develop a conceptual design meeting the above listed physical constraints and parameter requirements. Determine the expected performance through an extensive system level analysis/modeling effort. Identify technical risks and develop a risk mitigation plan.

PHASE II: Design, develop, and characterize a prototype a large format IRFPA or ladar receiver and demonstrate its functionality. Investigate private sector applications and commercialization of the large format IRFPA.

PHASE III: Develop a manufacturing process for the large format IRFPA or ladar receiver and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications. Specifically, FPAs and associated ROICs developed as a result of this SBIR topic will provide much needed sensitivity and resolution to sensors used in the medical field such as early breast cancer detection along with inexpensive collision avoidance sensors to be utilized in small private airplanes. FPAs and APDs produced as a result of efforts from this topic will be utilized by the law enforcement agencies on surveillance operations (drug trafficking, border patrol, etc.)

REFERENCES: 1. “The Infrared Handbook,” IRIA Series in Infrared and Electron- Optics, published by ERIM, 1993.

2. “MDA Infrared Sensor Technology Program and Applications,” M. Z. Tidrow, SPIE Proceedings, Vol. 5074 (2003), p39.

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4. J. S. Acceta and D. L. Shumaker, The Infrared and Electro-Optical Systems Handbook,” SPIE Optical Engineering Press, Bellingham, Washington, 1993.

KEYWORDS: Discrimination, IR Detectors, Ladar receiver, Active Sensors, Passive IR Sensor, Remote Sensing, Sensor Fusion, , Focal Plane Arrays, IR FPA.

MDA07-033 TITLE: Forecasting IR Satellite Imagery for Adaptive Sensor Tasking

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: DV, GM, TH, SN

OBJECTIVE: Develop advanced algorithms and software to forecast infrared (IR) satellite imagery for real-time sensor management and adaptive sensor tasking.

DESCRIPTION: The need to monitor the activities of nations hostile to the US requires the routine availability of ground imagery to detect and respond to military developments. Successful monitoring requires not only knowing what is currently occurring, but during periods of rapid activity, being able to monitor at the same selected location what occurs over a near-term future of several hours to days. Imagery provided by IR satellite sensors that are regularly used for such monitoring is strongly influenced by weather conditions that can have an adverse impact on intelligence gathering. Prior knowledge of environmental radiance conditions help facilitate sensor management. Proposals are sought for developing an innovative capability to forecast satellite imagery of ground terrain based on weather forecast information to meet intelligence mission planning surveillance needs. Proposed advances should address issues related to determining the state of the atmosphere from IR imagery, spatial resolution that is commensurate with satellite imagery, generating short-range forecasts of up to 72 hours for this atmospheric state through dynamical meteorological modeling, and producing forecast imagery as seen by IR sensors through radiative transfer modeling. Other key features should address computational speed for operational implementation, and predictive skill in forecasting satellite imagery.

PHASE I: Define an approach for determining an atmospheric state from IR imagery, and producing 72 hour forecasts of the imagery for the same location, for any bandpass of an IR sensor. Prototype a robust and viable algorithm for forecasting IR imagery and demonstrate the algorithm for a remotely-sensed ground terrain. Assess the computational feasibility of implementing the algorithm for operational implementation.

PHASE II: Evolve the approach developed in Phase I into a forecast capability. Demonstrate the potential and feasibility of the software for real world satellite mission scenarios in coordination with government personnel. Assess the predictive skill of the IR imagery forecast capability using well-defined statistical measures.

PHASE III: Transition forecast infrared (IR) satellite imagery prototype to DoD and commercial space satellite ground applications. Validate real-time ability to improve forecasting infrared (IR) satellite imagery for real-time sensor management and adaptive sensor tasking.

DUAL USE COMMERCIALIZATION: Military application: The technology will provide a forecast capability for IR imagery that will enhance intelligence mission planning surveillance. Commercial application: Results from this work will apply to weather forecasting and future NASA earth science missions.

REFERENCES: 1. Barry, Roger Graham, and Richard John Chorley, 2003, Atmosphere, Weather, and Climate, 170 pp., Routledge, Oxford, UK.

2. Berk, A., et al.(2000), Reformulation of the MODTRAN Band Model for Higher Spectral Resolution, paper presented at Algorithms for Multispectral, Hyperspectral, and Ultraspectral Imagery VI.

3. Berk, A., et al.(1998), MODTRAN Cloud and Multiple Scattering Upgrades with Application to AVIRIS, Remote Sens. Environment, 65, 367-375.

4. Mlawer, E. J., S. J.Taubman, P. D. Brown, and M. J. Iacono, and S. A. Clough, 1997, J. Geophys. Res., 102 (D14), 16,663-16,682.

5. Schowengerdt, Robert A, 2007, Remote Sensing, 3rd ed., Elsevier (Academic Press), San Diego, CA.

KEYWORDS: weather forecasting, satellite imagery, sensor management, adaptive tasking, intelligence surveillance

MDA07-034 TITLE: Device Level Thermal Management Solutions for Phased Array Radar

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: AB, DV, GM

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate low cost, manufacturable, chip-level thermal management solutions to reduce the operational junction temperature of high power RF power amplifiers.

DESCRIPTION: Wide bandgap semiconductors, namely GaN, have expanded the scope of device applications beyond those of silicon and gallium arsenide. Exploitation of wide bandgap semiconductors holds promise for revolutionary improvements in the cost, size, weight and performance of a broad range of military and commercial microelectronics. The intrinsic properties of GaN make it ideal for use in next generation microwave/millimeter wave radar applications. GaN power amplifiers are capable of operating at several times the power density of GaAs based devices. This enables more power on target which leads to longer range and/or decreased aperture size. Current GaN development programs are focused on demonstrating devices with 5-6W/mm of RF output power density. However, this power density does not reflect the true capability of GaN but rather a compromise between the desired RF performance and the realities of current thermal solutions. This new generation of high power microwave devices faces significant thermal challenges due to ever increasing power densities. Current GaN RF transistor performance is limited by localized heating in a very thin AlGaN epitaxial layer near the gate region. Due to its relatively low thermal conductivity, GaN is unable to effectively remove heat generated during device operation. The use of large metal heat-sinks with active cooling provides low thermal conductivity backgrounds, but cannot reduce the temperature near the submicron field-effect transistor gates. Efficient thermal management is essential for minimizing thermal energy near the transistor's active channel. Ideally, the optimal solution would be to integrate thermal management directly into the GaN device thus minimizing design challenges for the system integrator. Innovative concepts are sought that can satisfy advanced radar system requirements

PHASE I: Develop and demonstrate innovative materials and/or techniques capable of reducing device junction temperature without degrading performance, reliability or process ability.

PHASE II: Develop and demonstrate cost effective manufacturing processes. Validate thermal, reliability and cost benefits to be achieved through a prototype device demonstration. Identify radar components suitable for insertion utilizing proposed technology.

PHASE III: Target MDA industrial partners for technology transition with potential integration into one or more BMDS systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposed technology is expected to garner a high level of interest for next generation broadband communications and optoelectronics applications.

REFERENCES: 1. Francis, D., Wasserbauer, J., Faili, F., Babic, D., Ejeckam, F., Hong, W., Specht, P., Weber, E.R., "GaN-HEMT Epilayers on Diamond Substrates: Recent Progress," Compound Semiconductor Manufacturing Technology Conference, May 13-18, 2007, Austin.

2. Blevins, J., "Wide Bandgap Semiconductor Substrates: Current Status and Future Trends," Compound Semiconductor Manufacturing Technology Conference, May 2004, Miami.

KEYWORDS: Thermal management, wide bandgap semiconductors, GaN, power amplifiers, phased array radar, heat conduction

MDA07-035 TITLE: Innovative Hardware Technologies for Anti-Jam and Electromagnetic Attack Rejection in Ballistic Missile Defense System (BMDS) Radars

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: DV, GM, TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Identify, develop, and demonstrate novel or innovative advances in anti-jamming and electromagnetic attack protection hardware technologies that will support existing BMDS X-band, S-band, and other radar systems. The focus of this research is to develop and demonstrate hardware technologies that provide increased protection and/or mitigation of the radar from jamming, high power microwave (HPM), ultra wide band (UWB), and electromagnetic pulse (EMP) attacks.

DESCRIPTION: The BMDS radar threats envisioned for the near- and far-term are a challenging mixture of electromagnetic threats that include jamming, high power microwave attack, ultra wide band attack, and electromagnetic pulse attack among other countermeasures. These threats will require novel and innovative approaches in the radar to counter these measures and the development of effective radar protection devices. This technology research effort is focused on developing and demonstrating hardware technologies to defeat evolving advanced Electronic Counter Measures (ECM) and high-power, fast-rise-time HPM, UWB, or EMP attacks through the radar front end. New hardware technologies that provide improved protection for existing BMDS radars (SBX, FBX-T, THAAD, and AEGIS) will be developed. Key areas of research interest include novel or innovative techniques in advanced signal processing, adaptive beam control, pulse limiters, advanced noise filtering devices, as well as other hardware devices for increasing signal-to-jamming or signal-to-clutter ratios. Of particular interest are adaptive beam control techniques, as well as, passive devices capable of increasing the signal-to-noise ratio and/or providing the required ECM/HPM/EMP protection. Proposed approaches should include details of assumptions that impact the overall system performance or are required to facilitate the incorporation of the proposed technology.

PHASE I: Develop and demonstrate the feasibility of the proposed technologies for anti-jam and/or HMP/UWB/EMP protection. Demonstrations can be through hardware or models and simulations. Demonstration of the technology with either a brassboard or pre-prototype is preferred.

PHASE II: Refine/update concept(s) based on Phase I results. Evaluate/demonstrate the technology in a realistic laboratory environment to show the enhanced protection capability provided by the technology.

PHASE III: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed. This demonstration should show near-term application to one or more BMDS radar systems. Partnership with traditional DoD prime contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable to commercial air traffic control radar and commercial communications systems for anti-jam and EMI protection as well as protection of commercial equipment from EMP/HPM?UWB by terrorists groups. There also are numerous military applications outside of missile defense.

REFERENCES: 1. “Information Warfare Technology,” http://www.jya.com/mcsec09.pdf

2. Eileen M. Walling, “High Power Microwaves: Strategic and Operational Implications for Warfare,” Occasional Paper No. 11, February 2000, Center for Strategy and Technology, Air War, College, Air University, Maxwell Air Force Base, Alabama, http://www.globalsecurity.org/military/library/report/2000/occppr11.htm

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KEYWORDS: Anti-Jam, Electromagnetic Interference, Electromagnetic Pulse, High Power Microwave, Radar, X-Band, Electronic Countermeasures, Ballistic Missile Defense

MDA07-036 TITLE: Electrical Interconnect Technologies for MDA Phased Array Radars

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: GM, DEP

OBJECTIVE: Develop, demonstrate and test Advanced Interconnection Technologies which significantly increase Phased Array Radar performance through higher packaging density, increased application robustness and improved power dissipation when compared to conventional phased array technologies. The proposed technologies shall also demonstrate a significantly reduced cost as compared to conventional phased array technologies. Novel techniques employing existing materials for increased performance such as dense microstrip design, improved components or developing designs incorporating new materials/processes are both within the range of interest. The proposed approach must demonstrate that it can be taken to a TRL (Technology Readiness Level) of 5 by the end of a Phase III and that it is focused on a specific MDA/military system insertion Milestone.

DESCRIPTTION: MDA and military systems with limited or decreasing budgets are being required to increase system performance of existing system designs to be adaptable to an increasing number of application platforms and new threat scenarios. MDA requires higher performance electrical interconnect technologies which can be inserted during system upgrades to meet these requirements. Innovative use of existing materials and processes or new materials and processes are sought to improve the electrical interconnection of existing or planned systems while decreasing the cost and volume needed to realize the subsystems being replaced.

Electrical interconnection technologies are sought which can provide dense microstrip phased array radar technologies, this will require implementing both RF and digital devices within a multi-layer design with constrained interconnect spacing to meet the phased array design requirements, while providing low RF loss dielectric characteristics and dimensional stability to the array’s application environmental stresses such as mechanical shock & vibration, thermal and other environmental stresses. Proposals are sought that leverage commercial technologies for military use. Proposals that seek to utilize low cost nonhermetic packaging technologies that are robust enough to function throughout the lifecycle of their application are also sought. By the end of Phase III, the proposed technologies shall demonstrate a Technology Readiness level of TRL 5. The proposals must also demonstrate acceptable thermal management for MMIC’s attached to Printed Circuit Boards (PCB), acceptable interconnect design for reliable IO and backplane to antenna connections.

PHASE I: Demonstrate improved manufacturability of a radar array module. This design will select alternate components, new adhesive materials, or redesign to adapt to new/different manufacturing methods. Design an array module design that demonstrates improved yield and lower cost while maintaining or improving system RF performance. Establish preliminary cost and reliability test plan for the proposed technology approach.

PHASE II: Develop the proposed advanced module including power amplification on the card, distributed elemental amplifiers, bias capacitors, gain driver blocks and transmit/receive switches, etc as needed. Build, test, and characterize the card or developed subassembly performance and efficiency. Conduct initial cost modeling and selected portions of the reliability test plan, sufficient to show feasibility and potential of the design/technology to meet application stresses.

PHASE III: Establish final array design and manufacture a 2D array of the modules produced in Phase II mounted in a backplane and housing, with power supply and distribution network, and steering software to demonstrate 2D beam steering. Demonstrate high efficiency and high power density, conduct detailed cost model and conduct reliability tests to establish TRL 5 for the module hardware.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology is expected to be of interest to commercial radar systems applications requiring robust packaging.

REFERENCES:

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final.pdf

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4. “Linkages: Manufacturing Trends in Electronics Interconnection Technology,” National Academy Press, 2101 Constitution Avenue, N.W., Washington, DC. 20418. http://www.nap.edu/reportbrief/11515/11515rb.pdf

5. MDA RF Packaging Study for T/R Modules,” Final Report, December, 2004, American Competitiveness Institute, One International Plaza, Philadelphia, PA 19113. 3. “High Density Interconnect Technology” Technology Application Program, Spinoff Technology #439
http://www.mdatechnology.net/techsearch.asp?articleid=439#sec6

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KEYWORDS: Radar, Phased Array, Interconnections

MDA07-037 TITLE: <u>Distributed Aperture Radar Signal Processing Algorithms, Waveforms, and Signal Processing</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: DV

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Identify, develop, and demonstrate novel or innovative advances in distributed aperture algorithms, waveforms, and signal processing that will support existing and new Ballistic Missile Defense System (BMDS) X-band radar systems. The focus of this research is to develop and demonstrate technologies to enhance protection against mainlobe jamming effects.

DESCRIPTION: The BMDS radar threats envisioned for the mid-and far-term are a challenging mixture of electromagnetic threats. We are seeking novel and innovative approaches to enhance MDA protection against manilobe effects. This technology research effort is focused on developing and demonstrating technologies to defeat evolving advanced Electronic Counter Measures (ECM). Key areas of research interest include novel or innovative techniques in advanced signal processing, adaptive beam control, as well as other concepts for increasing signal-to-jamming or signal-to-clutter ratios. Of particular interest are multiple input multiple output (MIMO) distributed aperture adaptive beamforming techniques. The configuration of the apertures is expected to include multiple arrays distributed over 1 to 10 kilometers. Proposed approaches should include details of assumptions that impact the overall system performance or are required to facilitate the incorporation of the proposed technology. (This topic is not addressing track fusion from distributed sensors)

PHASE I: Research, develop and demonstrate the proposed technologies that address the wide field of interest identified in this topic. Demonstrations can be through hardware demos or models and simulations.

PHASE II: Refine concept(s) developed in phase I to allow near real-time demonstrations. Evaluate the phase I technology to demonstrate performance with wideband signals in a dense target and signal environment.

PHASE III: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed. This demonstration should show near-term application to one or more BMDS radar systems. Partnership with traditional DoD prime contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial applications include cell phones and smart antennas.

REFERENCES: 1. P. Calvary and D. Janer, "Spatio-temporal coding for radar array processing," Acoustics, Speech, and Signal Processing, 1998. ICASSP '98. Proceedings of the 1998 IEEE International Conference on, Volume:4, 12-15May1998, Pages:2509 - 2512 vol.4

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KEYWORDS: Distributed Apertures, STAP, MIMO, spatio-temporal coding, mainlobe cancellation

MDA07-038 TITLE: RF-Photonic Circuits and Interconnections for Radar Applications

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: AB, DV, TH

OBJECTIVE: Demonstrate robust photonic RF interconnections and components that will enable improved radar system performance while reducing system weight and volume. Current photonic –RF studies are establishing technologies that can provide improved link performance in terms of Spur Free Dynamic Range (SFDR), but these advances are still based on commercial photonic interconnects and components that were packaged for commercial environments and volume constraints. The commercial components have temperature dependent operation characteristics and are only designed and characterized to commercial environmental specification limits, operation of these components to military temperature extremes leads to reduced performance, reduced reliability. Photonic-RF interconnects and components are needed that can survive the temperature, packaging, environmental and functional operating performance required by applications of interest to MDA/Military systems. Research is needed to establish interconnections and photonic components which have improved electrical performance, 2X decreased size and weight while providing more environmentally robust packaging. These technology improvements are required to enable photonic – RF hardware insertion in space limited military platforms that have environmental constraints beyond what commercial hardware was designed to survive. Studies that address improved photonic-RF component performance over extended temperature and environmental ranges, that are 2X smaller, 2X lighter are needed. These developments should focus on an MDA/ military application need.

DESCRIPTION: Photonic interconnections and components are typically packaged for commercial applications and in general they are not packaged to survive the temperature extremes and environments typical of MDA/military systems nor do they satisfy the packaging density constraints of many space and weight constrained MDA/ military systems.1 The utilization of photonics within phased array radars can significantly increase system performance while reducing system weight. Proposals are sought to provide integrated photonics and photonic components that result in improved phased array radar system performance and lower cost. Proposals are sought that leverage commercial photonics technologies for military use. Proposed efforts shall study and extend existing dual use photonic hardware temperature and environmental operating ranges or develop new robust integrated photonic technologies. The proposed approach shall be capable of withstanding the application environmental extremes of intended MDA/military applications and it should focus on demonstration of hardware that is needed by an MDA/ military system. Proposals that seek to utilize low cost photonic packaging technologies that are robust enough to function throughout the lifecycle of their intended MDA/military application are sought. By the end of Phase III the proposed technologies shall have demonstrated a Technology Readiness level of TRL 5. Photonic interconnection and components offer numerous advantages to analog RF such as inherent wide bandwidths, reduced size, weight and signal remoting. Radar systems with severe environmental requirements/constraints will benefit significantly from low loss remoting, reduced size, weight and robust signal transmission. The goal of this topic is to advance photonic technology packaging and functionality to meet the demanding application environments and performance requirements of MDA systems.

PHASE I: Perform a feasibility study and an initial development effort that demonstrates a photonic circuit concept capable of providing increased radar performance with 2X reduction in size and weight that is robust enough to meet MDA/ military application temperature and environmental specifications.

PHASE II: Develop a prototype photonic circuit. Demonstrate the performance increase provided by the hardware over the current radar technology performance with 2X reduction in size and weight that is robust enough to meet MDA/ military application temperature and environmental specifications.

PHASE III: Production of robust application ready, TRL 5, photonic interconnections and components for utilization in MDA/military radar systems. Construct and demonstrate photonic technologies are suitable for system insertion both through improved system performance parameters and capable of operating in application temperature and environmental conditions.

PRIVATE SECTOR USE OF TECHNOLOGY: Photonic interconnections and components enabling high performance photonic links would find numerous applications in military systems as well as commercial systems for transportation systems.

REFERENCES: 1. M.W. Beranek, “Fiber optic interconnect and optoelectronic packaging challenges for future generation avionics,” Proceedings of SPIE, vol. 6478, 2007.

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KEYWORDS: Microwave Photonics; Photonic Links, Radar, Packaging

MDA07-039 TITLE: Distributed Real-Time Information Assurance Management Technologies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: DOS, RMS/RMRC

OBJECTIVE: Develop and demonstrate innovative solutions to the problem of distributed security management and assessment in the context of Ballistic Missile Defense System (BMDS).

DESCRIPTION: The BMDS consists of numerous heterogeneous components, many of which are IA enabled. It is critical for the security state of the system to be assessed based on the state of these components individually and collectively across the BMDS. Such a system should be fundamentally distributed, near real time, secure and provide the capability to manage, correlate and assess information assurance situational data throughout the BMDS. Novel solutions are being sought that are distributed and adaptable and focus on analysis, correlation, reporting, and alerts on computer network incidents as they relate specifically to missile defense systems and networks.

The sponsor is interested in alternative approaches that do not rely on centralized storage of IA data and incidents. The solutions should be distributed, build upon work already underway to address insider threats (see reference 1-3 below) and/or approaches that significantly extend the current state of the art for IDS systems. This sponsor is also interested in identifying activities that could be characterized as precursors to a malicious attack and/or correlating separate events in near real time across a wide area network. These capabilities are essential in order to manage complex distributed systems, particularly during periods of heightened alert on the BMDS. In addition, any proposed techniques must not impact the operational network.

Integrating the results of distinct monitoring efforts is the necessary precursor to achieving the situational awareness levels that support decision and action. Modular designs for the monitoring architecture are encouraged, as the ability to dynamically add new features in response to a changing environment is required. The sponsor will consider architectures that reside on virtualization technology. However, the intent of this SBIR is not to develop a trusted/secure Hypervisor, Measurement and Attestation technology, or similar architectures.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of methods for distributed, near-real-time, security management systems that provide comprehensive situational awareness of the Information Assurance state of the BMDS and its components.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates advancement of distributed near-real-time, security management systems that provide comprehensive situational awareness of the Information Assurance state of the BMDS and its components by illustrating functional effectiveness for a subset of BMDS components.

PHASE III: Prepare detailed plans for and implement demonstrated capabilities on critical military and commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Security Management technology has application throughout commercial industries. Commercial systems that are exposed to internet and corporate intranets would benefit greatly from this development. In addition to military and homeland defense, banking, finance, e-commerce, and medical industries would have a high demand for such systems.

REFERENCES: 1. Boudaoud, K. Labiod, H. Boutaba, R. Guessoum, Z. , Network Operations and Management Symposium, 2000. NOMS 2000. 2000 IEEE/IFIP “Network security management with intelligent agents” 2000.

2. Y. Xiong, Steve Liu, P. Sun, "On the defense of the Denial of Service Attacks: An On-Off Feedback Control Approach," IEEE SMC Transactions, Part A Special Issue on Information Assurance and Security, vol. 31, no. 4, pp. 282-293, July, 2001.

3. Wieselthier JE, Nguyen GD, Ephremides A: Mobile Networks and Applications 6: 251, 2001

4. [Heberlein90] L. T. Heberlein, G. V. Dias, K.N. Levitt, B. Mukherjee, J. Wood, and D. Wolber, A Network Security Monitor, Proceedings of the 1990 IEEE Symposium on Research in Security and Privacy, May, 1990.

5. Kahn, Clifford, et al. A Common ID Framework. (1998).

KEYWORDS: distributed real-time trusted management system, network security management, intrusion prevention, cyber security

MDA07-040 TITLE: Configuration Validation Technologies

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: DOS

OBJECTIVE: Develop and demonstrate innovative solutions to the problem of validating secure state and validated hardware/software baseline for computer systems that are returned to an operational status after having been in a test or development status.

DESCRIPTION: The BMDS is aggressively pursuing a capability to perform concurrent test, training, and operations. The goal for Concurrent Test, Training, and Operations (CTTO) is to be able to allocate Ballistic Missile Defense System (BMDS) resources to sustain mission operations while simultaneously conducting RDT&E, maintenance, training, qualification and certification, and system upgrade activities.
Operational assets must be able to transition from operational status to non-operational status, and then back to an operational status. It is of paramount importance to be able to verify that when an asset transitions to an operational status it is in a known and secure state. No hardware, software, or system settings that are not defined for operational status must remain when the system transitions to operational mode. Additionally, the environment will be dynamic;

a component/asset will need to transition to an operational status and must be ready for defensive operations on short notice.
Research is required into innovative techniques for validating that a computer system that transitions to operational status, after having been in a non-operational mode, is in a defined and secure state. This means that:

- only approved hardware and software must be in place;
- system settings and parameters be as defined for the secure state (e.g., operator and user permissions, privilege settings for applications and systems code);
- no extraneous hardware or software is being introduced into the operational environment;
- no required hardware or software has been removed.

The mechanisms employed must be capable of preventing not only inadvertent changes to the state and configuration of the operational asset, but also hostile attempts alter the asset in a way that would harm or degrade the BMDS mission, e.g., by the introduction of hostile code or extraneous or altered hardware.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of techniques and mechanisms for validating the state and configuration of operational BMDS assets.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates the ability to discover variances from the required operational configuration and state.

PHASE III: Prepare detailed plans for and implement demonstrated capabilities on critical military and commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Tools for validating a known, secure state also have application in civil and commercial arenas, for cases in which a secure configuration must be ascertained after an asset has been in maintenance, diagnostic, or development status. The commercial environment offers ample opportunity for malicious actions to be taken against, or malicious code to be introduced into computing assets that process sensitive data or provide critical capabilities.

REFERENCES: 1. Config-Model, Dominique Dumont; http://search.cpan.org/~ddumont/Config-Model-0.608/Model.pm

2. Configuration Management: Best Practices White Paper, Cisco; http://www.cisco.com/
warp/public/126/configmgmt.html

KEYWORDS: intrusion prevention, intrusion detection, malicious code, cyber security, Secure state

MDA07-041 TITLE: Security Policy Reconciliation

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: DOS

OBJECTIVE: The computing networks of Ballistics Missile Defense Systems (BMDS) are an important target for the enemy. One key area of critical importance to the BMDS is the ability to integrate computer systems, components and applications to perform an integrated mission implementing cooperative security policies.

DESCRIPTION: Research is required into the preservation of the security policy within a system, subsystem and application layers in complex systems. The sponsor is interested in the development of tools to support automated policy reconciliation and composition across a distributed enterprise level system of systems. In order to find gaps and inconsistencies in security policy specifications across an integrated system-of-systems, information must be extracted from those security policies highlighting semantic interoperability issues that could lead to weak or limited policy enforcement. Furthermore, both formal and semi-formal modeling techniques can be applied to validate the divergence of the policies among integrated components in order to complete the reconciliation of detected interaction vulnerabilities. These methods also support the composition of security policies.

Solutions must address composition problems for applications, systems, and be applicable to large-scale, dynamic, enterprise level systems in a system of systems context and accommodate multiple, evolving, and flexible device management protocols. The proposed solutions should be system-independent and build upon on-going research including the Department of Defense (DoD) Goal Security Architecture (DGSA).

PHASE I: Develop methods and tools that support security policy interoperation and application level certification and accreditation in a system of system context.

PHASE II: Continue development of technology based upon based on Phase I results and demonstrate technology in a realistic environment. Identify opportunities for transition of this technology into BMDS programs.

PHASE III: Pursue partnership with traditional DOD prime-contractors since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Technology that allows the analysis of complex systems, as it relates to the delivery of security capabilities, has application in the commercial sector. Examples include the financial, medical, and electronic based systems. In addition to military and homeland defense, banking, finance, and e-commerce industries would have a high demand for such tools.

REFERENCES: 1. Security Policies and Security Models - Goguen, Meseguer - 1982.

2. Information Flow in Non-Deterministic Systems Wittbold, Johnson - 1990.

3. A Model of Information - Sutherland – 1986.

4. Security and the Composition of Machines- Johnson, Thayer – 1988.

5. Hookup Security for Synchronous Machines- Millen – 1990.

6. A Hookup Theorem for Multilevel Security- McCullough – 1990.

7. A Formal Approach for Security Evaluation - McDermid, Shi – 1992.

KEYWORDS: composition, information security, information assurance, computer networks, security policy, security standards

MDA07-042 TITLE: Voice over IP Security

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: DOS

OBJECTIVE: Develop and demonstrate innovative solutions to the problem of enforcing and implementing security solutions for Voice over IP (VoIP) that can be controlled outside of private network boundaries.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) continues to implement newer technologies, such as VoIP. This has obviated the need for VoIP security mechanisms that can be enforced and implemented within a private network boundary which will also will be enforced and maintained outside of those boundaries. These same security mechanisms must NOT be impacted by boundary controls/protection mechanisms.

Without the ability to enforce security policies external to the private network, many security concerns arise. At the forefront of these concerns are privacy and confidentiality issues along with the additional considerations for existing firewall and network address translation policies and implementations. There are many other security concerns for VoIP implementations, such as authentication, integrity, denial of service, replay, or spoofing, which must also be taken in to account.

Research is required into innovative techniques for VoIP Security solutions that enforce security policies across network boundaries. This includes areas such as, but not limited to:

- port mapping and translation techniques
- validation techniques for sender/receiver response packets
- encryption and key management
- validation and maintenance of security policies as packets traverse multiple networks.

The mechanisms employed must be capable preventing various attacks on the voice traffic, such as spoofing, denial of service, and replay.

The sponsor is interested in solutions for a general COTS environment, where the network boundaries are not necessarily the dividing line between networks of differing security domains. However, the sponsor will also consider research that builds upon, but does not duplicate, the research done for MDA SBIR 2005-64 "XML Cross-Domain Voice Collaboration".

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of techniques and mechanisms for establishing secure VoIP within the BMDS.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates the ability to enforce the security policies necessary for communication within the BMDS.

PHASE III: Prepare detailed plans for and implement demonstrated capabilities on critical military and commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial industry has a widespread use of VoIP technologies. The proposals should demonstrate how the solution can benefit commercial businesses in addition to defense applications. The proposals should clearly define how the security solution will benefit commercial industry without performance degradation to services already provided.

REFERENCES: 1. Defense Information Systems Agency. Voice over internet protocol (VOIP) security technical implementation guide, 2004

2. Sinnreich, H. & Johnston A. (2001). Internet Communications Using SIP: Delivering VoIP and Multimedia Services with Session Initiation Protocol, John Wiley & Sons, Inc, 2001.

KEYWORDS: Voice over IP, cyber security, computer network

MDA07-043 TITLE: <u>Ballistic Missile Defense Anti-Tamper Volume Protection</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Space Platforms

ACQUISITION PROGRAM: DEP

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and implement new innovative anti-tamper (AT) volume protection technology for the protection of critical technology against exploitation.

DESCRIPTION: The MDA Director has issued a directive necessitating the protection of critical program information from unintentional transfer and the policy for the implementation of anti-tamper technology on MDA acquisition and associated technology programs. AT technology consists of engineering activities that prevent and/or delay exploitation of critical technologies in U.S. weapons systems. The purpose is to add longevity to critical technology by deterring efforts to reverse-engineer, exploit, or develop countermeasures against a system or component. This effort will focus on developing innovative AT techniques and technologies that provide protection from reverse engineering and compromise of both hardware and software. Attention will be placed on integration into weapons platforms and their associated hardware and software. As a result, the MDA will maintain a technological edge in support of the war fighters. Additional information on Anti-Tamper within the Department of Defense may be obtained at the DoD Anti-Tamper Executive Agent website, http://www.at.hpc.mil/index.htm.

The intended research area is the development of innovative volume protection technologies and techniques that can be;

- integrated and are compatible with commercial-off-the-shelf (COTS) and military hardware
- portable and re-usable.

A specific need exists for protection of Critical Program Information (CPI) between the U.S. developers' secure labs/facilities, and the in situ location of that technology in the fielded weapon system. Many current methods involve procedural physical security practices (e.g., two-person control) or rely on "dumb" tamper-evident protections which merely indicate that a tamper event may have occurred (e.g., someone opened this box). This topic seeks to identify methods to monitor and respond to tamper events that may lead to unauthorized access to critical program information (CPI). Though the particular solution may be tailored to an individual design, the concept and methodology of the solution should be applicable to various COTS and military hardware. Preference will be given to solutions provide active protection for Critical Technologies without introducing additional transportation risks (e.g., energetics, hazardous materials, etc.). Ideal submissions will guard against surreptitious breaches of the protected volume and overt exploitation attacks for items lost/stolen during transit.

PHASE I: The contractor shall develop the conceptual framework for new and innovative AT volume protection technology or technique that is integrated with, or tailorable to, the volume being protected. The contractor will also perform an analysis and limited bench level testing for an understanding of the new and innovative volume protection technology.

PHASE II: Demonstrate and validate the use of AT volume protection technologies into one or more prototype efforts and estimate the effectiveness of the techniques. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Integrate selected AT volume protection technologies into a critical system technology, for a BMDS system level test-bed. This phase will demonstrate the application to one or more MDA element systems, subsystems, or components and the products utility against industrial espionage. When complete, an analysis will be conducted to evaluate the ability of the technologies/techniques to protect against tampering in a real-world situation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve producibility or performance of products that utilize innovative process technology.

REFERENCES: 1. Wills, L., Newcomb, P., Eds. Reverse Engineering, Kluwer Academic Publishers, 1996.

2. Ingle, K. A. Reverse Engineering, McGraw-Hill Professional, 1994.

3. Furber, S., ARM System-on-chip Architecture, Addison-Wesley, 2000.

4. Huang, A. Hacking the Xbox: An Introduction to Reverse Engineering, No Starch, 2003.

KEYWORDS: Anti-Tamper, Volume Protection, Reverse Engineering, Exploit, Electronics

MDA07-044 TITLE: Debris Assessment from Spectrally Diverse Sensors and Air Sample to Aid Post-Intercept Weapons Typing

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: BC, AB, KI, GM, TH, AS

OBJECTIVE: Investigate techniques for weapons type assessment using airborne debris data from multiple, spectrally diverse sensors. This effort seeks to link debris cloud formation and projected fallout areas to potential ground-, sea-, air-, and space-based sensors. Efforts should fuse both RF and EO/IR algorithms and, where appropriate, analyze success of fused solutions.

DESCRIPTION: This topic develops techniques, features, and measurements to evaluate the multi-spectral phenomenology associated with intercepted objects, as well as sensor data associated with debris fallout and recovery. These techniques, features, and measurements will be used to aid in weapons typing of post-intercept debris. Topic develops techniques for assessing debris and quantifying confidence in assessment as a function of time, including RF, EO/IR, and air-sampling sensors. Often within a region of operations there will be multiple elements that have opportunities of engagement at different parts of the timeline, presenting a global debris assessment challenge.

PHASE I: The contractor should demonstrate the ability to integrate spectrally diverse sensor data and formulate hypotheses about weapon types. A demonstration of this type should be based on an understanding of the theoretical basis and various real-world assumptions of sensor capabilities.

PHASE II: The contractor should further develop the technology to enable a relevant demonstration of weapons typing and explore the parameter sensitivity of the technique. The contractor should demonstrate the capability to integrate multiple components in a way that is suitable for application at the BMDS, C2BMC level.

PHASE III: The contractor will work toward technology integration into the BMDS System with the C2BMC Program Office and other associated Program Element Offices. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: RF based satellite or Space Shuttle damage assessment, NASA. RF and IR based debris assessment for first responder support functions. Optical Recognition and correlation systems.

REFERENCES: 1. Eugene Knott, John Shaeffer, Michael T. Tuley, Radar Cross Section, Second Edition, Norwood, MA, ARTECH HOUSE, 1993.

2. August Rihaczek, Steven Hershkwitz, Radar Resolution and Complex-Image Analysis, Norwood, MA, ARTECH HOUSE, 1996.

KEYWORDS: Weapons Typing, Kill assessment, discrimination, RF/IR mutli-spectral fusion

MDA07-045 TITLE: Automated Battle Management / Planning Aids

TECHNOLOGY AREAS: Information Systems, Space Platforms, Human Systems, Weapons

ACQUISITION PROGRAM: DV, BC, GM, SN, DEE

OBJECTIVE: To develop advanced, innovative, robust, real-time interceptor to target assignment algorithms and software that also support the warfighters' decision-making processes within a coordinated, layered missile defense environment.

DESCRIPTION: With the addition of emerging weapon systems, to include boost intercept capability (airborne laser or kinetic interceptor), upgraded SM-3 missiles, kill vehicle systems, and terminal defense systems, the Ballistic Missile Defense System (BMDS) will have the capability for layered defense. To maximize the potential performance enhancements of these new weapons and of the associated battle management and fire control systems supporting them, it is necessary to extend the ability of assignment algorithms and decision theory. For single kill vehicle systems this will require determination of the number and location of each interceptor type to allocate to any threat. Because there is always the possibility for operator override, the degree to which the warfighter interprets and understands the system behavior appropriately should be assessed. This topic will require advanced optimization or assignment techniques, and/or expertise in human-machine interaction. Furthermore, to support any evolving defense structure, the proposed method should work in either a centralized or distributed architecture.

This topic can be divided into three functional areas. While the basic techniques developed will likely have applicability to all three areas, the areas have different constraints and requirements on processor capability and timeliness. Therefore, it is appropriate that proposals address one of the three areas explicitly.

First, the battle manager needs to allocate weapon systems and interceptors to threat launch events. This decision might be based on perceived threat inventory, complexity of the threat missile, and asset being attacked. This decision should depend on the capabilities of the weapon systems employed.

Second, the fire control needs to determine how best to employ the missiles allocated for negation of a threat launch, given that there might be multiple objects associated with each missile launch. This optimization should, where possible, exploit launch timing flexibility and any scope for trajectory shaping to control engagement geometry, and where appropriate, be capable of recognizing the opportunities for exploiting shoot-look-shoot engagements so as to maximize the probability of lethal object destruction. It should have the capability to adapt in real time to updated kill assessment and discrimination status information.

Third, the battle manager and fire control need to provide rationale to operators for the allocation of interceptors to targets. Operators will also use this information in determining (whether or not and) how to redistribute interceptors if necessary. The impact of different algorithms on operator interpretation, behavior, and performance should be studied in detail. Initiatives should include means for enabling the system to explain the rationale behind this computation to the warfighter clearly in a stressful, time-sensitive environment.

PHASE I: Develop the mathematical basis for and provide a demonstration of advanced allocation methods that will enable robust engagement planning for various weapon systems, battle managers and fire controls with different capabilities. Guidance will be provided on representative scenarios for concept evaluation. Concepts can be demonstrated on related problems of commensurate difficulty.

PHASE II: Develop/update the technology based on Phase 1 to provide a demonstration of the technology in a realistic environment using realistic data and operator interaction, to include realistic processing speeds in complex scenarios.

PHASE III: Integrate the technology into the BMDS system in coordination with BMDS System Engineering and the Element Program Office. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to any allocation/optimization application that operates on components of differing capabilities. This work will also contribute to research and development in human decision-making aids across a variety of areas including small business processes, collaborative work, and commercial and professional training.

REFERENCES: 1. Report of the American Physical Society Study Group, Boost Phase Intercept Systems for National. Missile Defense, Scientific and Technical Issues, July 2003.

2. Bertsekas, D.P., Dynamic Programming and Optimal Control, Athena Scientific, Belmont, MA, 2001.

3. Cannon-Bowers, J. & Salas, E. (1998). Making Decisions Under Stress: Implications for Individual and Team Training. Washington, DC: American Psychological Association.

4. Hosein P. and Athans, M., The Dynamic Weapon-Target Assignment Problem, Proceedings 1989 Symposium on Command and Control Research, Washington, DC, June 1989.

5. Klein, G. & Miller, T. (1999). Distributed planning teams. International Journal of Cognitive Ergonomics, 3(3), 203-222.

6. Lianos D., Strickland B., A midcourse Multiple Kill Vehicle Defense Against Submunitions 6th Annual. AIAA/BMDO Technology Readiness Conference, San Diego, CA, August 1997.

7. Paschal N., Strickland B., Lianos D., Miniature Kill Vehicle Program, 11th Annual AIAA/BMDO. Technology Conference, Monterey, CA, August 2002.

KEYWORDS: Optimization, Adaptive Scheduling, Allocation, Engagement Planning, interceptor, Ballistic Missile Defense Systems (BMDS), Human-Machine Interaction (HMI), Human Performance, decision-making, cognitive psychology

MDA07-046 TITLE: Track Correlation / Sensor Netting

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: DV, BC, GM, SN, DEE, SS

OBJECTIVE: Develop advanced, innovative, robust, real-time algorithms and software for the integration of passive or active electro-optical sensor tracks or detections with radar generated tracks or detections.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) employs optical and radar sensors in the detection, tracking, and identification of ballistic missiles and their constituent pieces. To provide a single integrated picture of the battle to the combatant commander and to the battle management algorithms, it is necessary to correlate (associate) the tracks and/or detections from the optical sensors with the tracks and/or detections from the radar sensors. Proposed advances should provide robust, reliable capability to correctly correlate reports from three or more sources (two sensors with the existing system track), or identify when the reports represent new tracks. The proposed approach should have the following properties:

1) Use metric data, features, or other data that provides for accurate correlation.
2) Provide a measure of confidence with the correlation decision.
3) Identify groups of objects that form a cluster but are otherwise indistinguishable.
4) Provide as many distinct tracks as possible, using track fusion when appropriate to increase overall track accuracy.
5) Provide for cluster tracks when absolutely necessary.

It is desired that the proposed method can be implemented in either a centralized or distributed architecture.

Proposals that offer improvements to track correlation subroutines, such as bias estimation or search routines, or that enable distributed operations will be considered.

PHASE I: Develop the mathematical basis for and provide a demonstration of track correlation/sensor netting concepts using simulated data.

PHASE II: Develop/update the technology based on Phase 1 to provide a demonstration of the technology in a realistic environment using realistic data, to include realistic processing speeds in complex scenarios.

PHASE III: Integrate the technology into the BMDS system in coordination with BMDS System Engineering and the Element Program Office. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control and multi-sensor applications.

REFERENCES: 1. Bar-Shalom, Y. and Blair, W.D., Editors, Multi-target/Multi-sensor Tracking: Applications and Advances, Vol III, Artech House, Norwood, MA, 2000.

2. Cowley, D.C. and Shafai, B., “Registration in Multi-sensor Data Fusion and Tracking”, Proceedings of the American Control Conference, June 1993.

3. Blackman, S., and Popoli, R., Design and Analysis of Modern Tracking Systems, Artech House, 1999

KEYWORDS: Track correlation, Sensor Fusion, Data Fusion, Multi-sensor

MDA07-047 TITLE: Slow Cook-Off Insensitive Munitions Solutions for Solid Rocket Motors

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: AB, GM, KI, QS, TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate an insensitive munitions (IM) solutions for a large diameter (12 inches or greater) solid rocket motor that improves the results of the slow cook-off test.

DESCRIPTION: Federal law requires all munitions to be as IM compliant as is practicable. An IM compliant munition passes each of the six IM tests outlined by Mil-Std-2105C and the NATO Standard Agreements (STANAGs). Currently there are solutions available to munition and system designers which improve IM response in impact events and fast cook-off. However, no solution exists for slow cook-off that either reduces the reaction violence or allows the munition to achieve only a burning reaction. The slow cook-off test is particularly hard to pass with just a burning reaction. The test requires the munition to be placed in an oven and heated at 3° C per hour till reaction occurs. The preferred reaction is no reaction to just burning.

This topic encourages approaches to lessen the SRM reactions to slow cook-off through design and development of novel mitigation techniques. Current solutions try to delay reaction which usually results in a more violent reaction, thus making the munition fail the test. The goal of this topic is to develop a solution which does more then prolong the reaction but actully reduces or eliminates the reaction violence to just burning.

PHASE I: Show understanding of the slow cook-off test and collect data on previously conducted slow cook-off tests which can be used in technology development. Develop a prototype of the solution at either a bench or analog scale. Test the prototype by simulating or replicating the slow cook-off test. Outline how the solution can be applied to a MDA system.

PHASE II: Refine the solution. Demonstrate the solution on a solid rocket motor model at either analog scale or scaled to use the proper diameter of 12 inches or greater in a slow cook-off environment. Outline how the solution should be transferred into a MDA system and what additional testing would be needed for complete system integration. Develop a release package that can be used to showcase the technology to potential programs.

PHASE III: Continue refining the solution. Complete any additional required testing and begin integration into a system. Work with industry and government labs to introduce the technology into a missile program.

COMMERCIALIZATION: Development of insensitive munitions technology in support of military and commercial research is rapidly-growing scientific endeavors. The proposed effort would be extremely useful in providing data to ensure the safety of personnel exposed to explosives in commercial space flight applications.

REFERENCES: 1. “Experimental Support of a Slow Cook Off Model Validation Effort” by Alice Atwood, November 2004

2. “Department of Defense Acquisition Manager’s Handbook for Insensitive Munitions” Rev 01, January 2004

3. “Insensitive Munitions Technology for Tactical Rocket Motors” by Andrew Victor 1994

4. NATO’s Munitions Safety and Information Analysis Center (MSIAC, formerly NIMIC)

5. “US DOD IM Program” by Anthony J. Melita (http://ww.dtic.mil/ndia/2003gun/mel.pdf)

KEYWORDS: case design, insensitive propellants, solid rocket motor design, booster, missile, ballistic protection

MDA07-048 TITLE: Safe Liquid Hypergolic Propulsion Systems

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: AB, GM, KI, QS, TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate a liquid hypergolic propulsion (LHP) system for missiles that can be demonstrated to be safe for storage, handling, transportation and shipboard use.

DESCRIPTION: The state-of-the-art for (LHP) systems has improved considerably over the years. Currently, there exist liquid propellant motors that are considered safe for production, handling, and shipping when they are used in ground-launched missile systems. However, to date, the US Navy, through the Weapons Systems Explosive Safety Review Board (WSESRB), has never approved hypergolic liquid propellants for surface ship applications also the US Air Force has limitations on shipping LHP systems.

However, there is a growing need to sea-base and air transport missiles with the performance characteristics inherent in liquid propellant rocket motors. There are new technologies that could be applied to convince the experts that guided missiles with LHP systems can be safely used aboard ship and air transport. This topic seeks innovative system approaches that can be demonstrated to address shipboard safety concerns.

By systems approach means technology that greatly reduces or eliminates the chances of an accident or inadvertent ignition, provides sensors for the same, and provides effective mitigation of any reaction in case of an incident. Convincing the experts means providing sufficient data for a program to use to gain acceptance from the WSESRB and air transportation boards. Included would be demonstration of compliance with insensitive munitions requirements and hazard classification tests.

Although the interest of the Missile Defense Agency is with ballistic missile interceptor propulsion, other systems which utilize hypergolic should be considered such as kill vehicles and divert attitude control systems.

PHASE I: Show understanding of the safety problems with different types of hypergolic systems. Propose technology solutions or system approach solution to improve the safety of LHPs. Design and conduct proof-of-principle demonstrations. Prepare paper outlining the safety benefits and improvements of the technology or system.

PHASE II: Develop a small-scale LHP system or technology demonstration to show its safety ability, considering Navy shipboard applications. Conduct hazard classification and insensitive munitions tests as deemed appropriate. Provide a plan for introducing the proposed LHP system or technology.

PHASE III: Work with industry and government labs to plan the introduction of the technology in energetics development programs. Prepare for release of data to the hypergolic community.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The development of a safer hypergolic system would be extremely useful to ensure the safety of personnel exposed to LHP systems in commercial space applications as well as other commercial industries which employ the use of hypergolic.

REFERENCES: 1. MIL-STD-882D, "Standard Practices for System Safety," 10 February 2000

2. "Modern Engineering for Design of Liquid-Propellant Rocket Engines," Huzel & Huang, pub. AIAA, 1992

3. "History of Liquid Propellant Rocket Engines," G. Sutton, pub. AIAA, 2005

4. "Hazard Assessment Tests for Non-Nuclear Ordnance", Military Standard, MIL-STD-2105C

5. "US Navy Insensitive Munitions Requirements," Navel Sea Systems Command, NAVSEAINST 8010.5B, 5 Dec 1989

KEYWORDS: Hypergolic fuels, hypergolic liquid propulsion, shipboard safety

MDA07-049 TITLE: <u>Insensitive Munitions Solutions for Large Scale Solid Rocket Motors</u>

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: AB, GM, KI, QS, TH

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OBJECTIVE: Using a component level or system level approach, develop novel and innovative insensitive munitions (IM) solutions for large scale (12 inches in diameter or greater) solid rocket motors (SRM). The approach can address the motor itself or any part of the missile system in which it is housed.

DESCRIPTION: Federal law requires all new and previously-developed munitions to be born or become IM compliant. Currently available IM solutions provide specific solutions to specific systems, threats and tests but are not necessarily able to translate between systems or threats. Examples include thermally initiated venting systems (TIVS) which protect against fast-cook off or fuel fire but not necessarily slow cook-off. Ballistic protection protects against bullet and fragment impact, but adds weight to the system. It is also important to note solutions that work on smaller diameter SRM systems may not translate well to larger diameter SRM systems.

It is important to remember when developing solutions that cook-off tests continue to reaction while impact tests use 50-cal AP rounds or 8300 ft/sec fragments. Even with current IM technology in place these tests can still produce violent reactions. Thus, it is critical that developed solutions reach beyond the current state of the art. The solutions should provide protection against an array of IM threats and still be practicable.

The topic is requesting novel solutions that are either completely new or build off the current state of the art, show a measured improvement in IM performance, and can be easily integrated into a system. The solution must not significantly limit or reduce the functionality and usability of the system. The proposal should also clearly and specifically outline how the technology will affect and benefit the IM properties of the SRM or system.

PHASE I: Outline the proposed solution, develop a test procedure, and provide proof of concept demonstration. The proof of concept demonstration can be shown by modeling and simulation or by a bench or analog scale model. The concept should be demonstrated in conditions that are representative the IM test for which it addresses. An outline of how the technology could be fitted into or used by a current system should be included in the final report.

PHASE II: Improve the technology. Refine the test plan and be able to provide a prototype and demonstration at the end of phase II. The prototype demonstration should clearly show how the solution will operate under IM test environments. If feasible, the solution should be demonstrated on an analog or sub-scale size motors, but this is not required. Develop a detailed technology transition plan identifying and addressing any possible technological hurdles that may hinder the technology transfer. Begin work necessary to transition the solution to either industry or a MDA element or system.

PHASE III: Continue improving and testing the technology. Work with industry and government labs to introduce the technology to energetics and missile development programs.

COMMERCIALIZATION: Development of insensitive munitions technology in support of military and commercial research is rapidly-growing scientific endeavors. The proposed effort would be extremely useful in providing data to ensure the safety of personnel exposed to explosives in commercial space flight applications and in commercial transportation of energetic components or systems.

REFERENCES: 1. “Department of Defense Acquisition Manager’s Handbook for Insensitive Munitions” Rev 01, January 2004

2. “Insensitive Munitions Technology for Tactical Rocket Motors” by Andrew Victor 1994

3. NATO’s Munitions Safety and Information Analysis Center (MSIAC, formerly NIMIC)

4. “US DOD IM Program” by Anthony J. Melita (http://ww.dtic.mil/ndia/2003gun/mel.pdf)

KEYWORDS: insensitive propellants, solid rocket motor design, booster, missile, ballistic protection

MDA07-050 TITLE: High Pressure Singlet Delta Oxygen Generator

TECHNOLOGY AREAS: Air Platform, Sensors, Weapons

ACQUISITION PROGRAM: AL

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OBJECTIVE: Improve Airborne Laser (ABL) Chemical Oxygen Iodine Laser (COIL) power, efficiency, pressure recovery and handling in an operational environment.

DESCRIPTION: The ABL COIL creates a lasing medium by producing Singlet Delta Oxygen (SDO) which in-turn dissociates an Iodine molecule and excites the Iodine atom for lasing. This SDO is the primary power supply for the laser and improving its delivery method is the focus of this effort. For a number of reasons current Singlet Delta Oxygen Generators (SOGs) operate at low pressures. If the pressure of the SOG can be increased while maintaining the efficiency of delivery then the improved delivery rate could translate to increased power as well as improved pressure recovery. It is also required that the eventual end product be utilized in the operational environment of the ABL, utilize state of the art light weight chemically resistant materials and be capable of being easily serviced. The desired end product would be a Preliminary Design of a Line Replaceable Unit (LRU) for reliably and precisely metering SDO to an individual ABL laser module.

If these results are realized, it would provide significant synergistic benefits to the ABL weapon system to include reduced payload weight and more reliable operation.

Proposals for accelerated development are strongly encouraged.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Select the most promising approaches and conduct modeling or subscale experiments of the most promising concepts that have a clear traceability to the ABL system. Based on results, develop a Preliminary Design for a 1/40th scale device and Phase II Program Plan for the design, fabrication and test of the subscale device to validate the selected concept. Planned tests should include a full suite of instrumentation to clearly validate the device chlorine utilization, SDO yield and water vapor pressure.

PHASE II: Execute the Program Plan developed in Phase I as directed by the government. Conduct fabrication, integration, testing, and test reporting for the 1/40th scale device as specified in the proposed Program Plan. This test report must discuss fully how key technical challenges were overcome and risks mitigated. Demonstrate clear traceability to a full-scale device and conduct a Preliminary Design for a 1/10th scale device. Develop a Phase III Program Plan that will include your design, fabrication, integration and test strategy for a 1/10th scale device. Identify remaining key technical challenges, risks, and risk mitigation strategies.

PHASE III: Design and build a 1/10th scale SOG, demonstrating device light weighting and maintenance advantages in a laboratory environment. Perform tests on the prototype, demonstrate its traceability to a full scale device and provide a detailed evaluation report. Provide a preliminary design of a full scale prototype LRU SDO generator.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Improved SDO generation has potential for numerous commercial applications such as chemical and biological decontamination processes. Improved pressure recovery would make the COIL more attractive commercially. Improved COIL processes also stand to benefit the industrial use of high power lasers for welding, cutting, and other material process applications which require lasers with high power output and excellent beam quality.

REFERENCES: 1. Carroll, D.L., King, D.M., Fockler, L., Stromberg, D., Madden, T.J., Solomon, W.C., and Sentman, L.H., “COIL for Industrial Applications,” AIAA-98-2992, p. 1-11 (1998).

2. Manke II, Gerald C. and Hager, Gordon D., “Advanced COIL – physics, chemistry and uses,” Journal of Modern Optics vol. 49 no. 3/4, p.465-474 (2002).

3. Vetrovec, John, “Prospects for an Industrial Chemical Oxygen-Iodine Laser,” SPIE vol. 2092, p.723-726 (1996).

KEYWORDS: Airborne Laser, Chemical Oxygen Iodine Laser (COIL), Singlet Delta Oxygen

MDA07-051 TITLE: Advanced Hemispherical Reflectance Measurement of Heated Materials

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: AL

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OBJECTIVE: Determine hemispherical reflectance during high power laser engagements in a laboratory environment

DESCRIPTION: The ABL lethality program has been tasked with determining the vulnerability of boosting missile against a laser weapons system. In order to determine the irradiance requirements, the absorption of the energy into the target must be known. Current hemispherical reflectance capability usually incorporates a moderately powered heating laser to induce measurable changes in the sample being measured. Recent studies have shown that the time-evolution of the reflectivity can be dependent on heating rate and the dependency can be considerable for particular materials. In this topic we seek measurement techniques and sensor systems to address the need to incorporate high heating rates to samples for hemispherical reflectance and transmission measurements on samples under representative HEL heating rates (100 of degrees per second).

Proposal presenters are encouraged to show the development and sensor/hardware path to obtain a functioning hemispherical reflectance/transmittance device that can obtain measurements at heating rate up to 500 degrees C per second, for time durations of at least 10 seconds. Lower heating rates must be able to sustain longer time durations (100deg/sec for at least 50 seconds). In addition, the device should be capable of handling targets as large as 1 meter by ½ meter with an active detector area of 30 centimeters. The device should be usable indoors and outdoors. The device must be transportable and must be able to be calibrated in less than 2 hours.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Select the most promising approaches and conduct modeling and sensor/hardware section of alternative concepts. Develop a Phase II Program Plan for further, more detailed modeling and sensor/material selection of a subset of the current concepts as well as for utilizing a subscale test device to validate selected concepts.

PHASE II: From the concepts modeled in Phase I, accomplish a further down select and conduct detailed modeling and sensor/hardware selection of the remaining competing concepts. Based on the results of this analysis, prioritize the remaining concepts for testing. Conduct integration, testing, and test reporting as specified in the proposed Program Plan. This report must discuss fully how key technical challenges were overcome and risks mitigated. Demonstrate how linkage could be made to a fully functioning device. Develop a Phase III Program Plan that will include your integration and test strategy for a full scale device capable of handling the 1 meter by ½ meter sample. Generate concept requirements, calibration and testing guidelines based on requirements for the full scale device. Identify remaining key technical challenges, risks, and risk mitigation strategies. This plan should include proposals for actual lasing tests on a target of the government’s choice and confirm operation and reflectance/transmission and absorbtivity values either in-house, at a contractor facility, or in a government laboratory. Propose specific, high payoff technology transfer applications and experiments.

PHASE III: Design and build a full scale functioning hemispherical reflectance device, demonstrating its ability to be calibrated against a known source, testing under laser engagement and data collection providing hemispherical reflectance/transmission and calculating absorption in a laboratory environment. Perform lasing tests on the sample and provide a detailed evaluation report of the device. Show near term application to one or more MDA element systems, subsystems, or components and investigate technology transfer applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More applicable measurements to be used in other areas including calculations of eye safe requirements applicable to filed testing high energy lasers.

REFERENCES: 1. Freeman, R.K., Rigby, F.A., Doerr, S.E., Grimes, L.E. & Ward, D.B. 1998, Reflectance of laser-damaged spacecraft thermal control materials.

2. Freeman, R.K., Rigby, F.A. & Morley, N. 2000, Temperature-dependent reflectance of plated metals and composite materials under laser irradiation.

KEYWORDS: Airborne Laser, hemispherical reflectance, Temperature dependant reflectance, Temperature dependant transmission

MDA07-052 TITLE: Fiber Optic Gyro (FOG) Performance Improvement

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: AL

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OBJECTIVE: Develop and demonstrate innovative, revolutionary approaches to improve fiber optic gyro (FOG) performance with minimal impact to size, weight, and volume of existing systems.

DESCRIPTION: Proposed MDA systems, such as Airborne Laser (ABL) require extremely high-resolution Line of Sight (LOS) stabilization and extremely accurate inertial pointing knowledge. In order to achieve the mission objectives, they require ultra high performance inertial angular sensors to provide absolute inertial line of sight knowledge and the necessary low frequency sensor information to support control system LOS stabilization for the pointing and tracking system. In addition, these systems need to be compact and lightweight due to their physical mounting locations within the system. Traditionally, improved performance in fiber optic gyros is gained by increasing the total length of fiber used in the gyro. This results in very large diameter gyros which become challenging to package for line of sight stabilization and pointing applications. ABL is interested in innovative, revolution approaches to overcome this limitation and produce extremely accurate gyros in a very compact form factor. Offerors my propose improvements in specific fiber optic gyro components or a new fiber optic gyro design that meets the governments expressed goals. Alternative sensor technologies may be submitted if they can demonstrate the desired performance and stability in a compact form factor.

The goals presented in this topic are strictly focused on the development and demonstration of innovative approaches to improve fiber optic gyro performance with minimal impact to size, volume of weight of current devices. However, the end goal (Phase III effort) is to create a high performance inertial angular sensor of compact form factor that meets ABL performance goals under their demanding operational environment. The goals presented below are specifically tailored to support operations within the ABL flight environment, under extreme slew maneuvers, and in precision track.

Performance Goals - Airborne:

| | Near-term Goal | Far-term Goal |
|---|---|---|
| Bias Drift Stability, 1 ó, 8 hr | < 0.0005 deg/hr | < 0.00001 deg/hr |
| g-sensitive bias drift | < 0.001 deg/hr/g | < 0.0005 deg/hr/g |
| Scale Factor Error (Long-term) | < 5 ppm | < 1 ppm |
| Angular Random Walk | < 0.00005 deg/(hr)1/2 | < 0.000001 deg/ (hr)1/2 |
| Angular Cross-axis Sensitivity | < 0.1% | < 0.01% |
| Linear Acceleration Sensitivity | < 1e-6 rad/g | < 1e-7 rad/g |
| Alignment Calibration Stability | < 1 arc-sec | < 0.5 arc-sec |
| Angular Rate capability | > + 2.3 rad/s (w/o change in measurement mode) | |
| Angular Acceleration Capability | > + 4.4 rad/s2 (w/o change in measurement mode) | |
| Power consumption | < 2 W/unit | < 1 W/unit |
| Size | <4” Diameter x 3” height | <3” Diameter x 2” height |
| Mass | < 0.75 kg per device | <0.5 kg per device |
| Operating temperature range | -54 to 32 C | |
| Survivable temperature range | -54 to 71 C | |

PHASE I: Develop a preliminary design for the identified components and/or sensor to demonstrate approach/design will meet above performance. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate the offeror understands the physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how near-term goals will be met, at a minimum. Proof of concept hardware development (laboratory breadboard) and test is highly desirable. Proof of concept demonstration may be subscale and used in conjunction with MS&A results to verify scaling laws and feasibility. Although not required, Offeror's are highly encouraged to team with manufacturers capable of incorporating the developed technology into useable product lines. The Government will not provide contact information.

PHASE II: Complete critical design of prototype components and/or sensor including all supporting MS&A. Fabricate a minimum of two devices (preferably four) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. Although not required, Offeror's are highly encouraged to team with manufacturers capable of incorporating the developed technology into useable product lines. The Government will not provide contact information.

PHASE III: Work with a commercial company or independently develop single sensor product line based on the technology developed in Phases I & II.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Current high performance IRUs cost $1.5M and up depending on customer unique requirements. A low cost system that can meet these requirements would be very competitive. These sensors are critical components in optical inertial reference unit (IRU) technology. Airborne Laser (ABL) already utilizes an optical IRU to determine and maintain accurate line of sight to their targets and have indicated a need for improved capability in future upgrades. Optical IRUs are/will be used in systems such as Airborne Tactical Laser, future space-based and ground based surveillance systems, and future space-based directed energy weapon systems to maintain precise line of sight knowledge and stability. A sensor meeting the desired goals would also have great impact on guidance, navigation and control systems for launch vehicles, missiles, KVs and other applications requiring precision inertial knowledge. Non-DoD applications include spacecraft guidance, navigation and control (GN&C), active suspension systems, large 6-dof vibration test systems, manufacturing robotic control sensors, and commercial aircraft inertial navigation systems (INS).

REFERENCES: 1. Subset of Standards Maintained by the IEEE/AESS Gyro and Accelerometer Panel

2. 528-2001 IEEE Standard for Inertial Sensor Terminology (Japanese translation published by the Japan Standards Association)

3. 529-1980 (R2000) IEEE Supplement for Strapdown Applications to IEEE Standard Specification Format Guide and Test Procedure for Single-Degree-of-Freedom Rate-Integrating Gyros

4. 671-1985 (R2003) IEEE Standard Specification Format Guide and Test Procedure for Nongyroscopic Inertial Angular Sensors: Jerk, Acceleration, Velocity, and Displacement

5. 813-1988 (R2000) IEEE Specification Format Guide and Test Procedure for Two-Degree-of-Freedom Dynamically Tuned Gyros

6. 952-1997 IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Interferometric Fiber Optic Gyros

KEYWORDS: Gyroscope; rate sensors; Inertial Pointing, Line of sight (LOS) stabilization; Acquisition, Tracking and Pointing (ATP); beam control

MDA07-053 TITLE: Improved Iodine storage, shipping, handling and operations for COIL Lasers

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: AL

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OBJECTIVE: Improve the method by which the Airborne Laser (ABL) Program can obtain very high purity Iodine and safely store, ship, handle and utilize it in an operational environment.

DESCRIPTION: The ABL Chemical Oxygen Iodine Laser (COIL) creates a lasing medium by producing Singlet Delta Oxygen (SDO) which in-turn dissociates an Iodine molecule and excites the Iodine atom for lasing. This Iodine is an extremely caustic substance and requires great care when storing, shipping and handling. The Iodine must also be quite free of impurities, especially water. Additionally, the Iodine, mixed with Helium, must be capable of being precisely metered into the laser system with short notice. Finally, it is required that the product be utilized in the operational environment of the ABL while being capable of being easily serviced. The desired end product would be a Line Replaceable Unit (LRU) for reliably and precisely metering Iodine to an individual ABL laser module.

If these results are realized, it would provide significant synergistic benefits to the ABL weapon system to include reduced payload weight, more reliable operation, a safer operational environment and a reduced logistics footprint.

Proposal presenters are encouraged to show methods for delivery of high purity Iodine to the COIL laser cavity while achieving safer, more efficient methods for storage, shipping and handling, and maintaining efficiency in an operational environment. Proposals for accelerated development are strongly encouraged.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Select the most promising approaches and conduct modeling or subscale experiments of the most promising concepts that have a clear traceability to the ABL system. Based on results, develop a Preliminary Design for a 1/10th scale device and Phase II Program Plan for the design, fabrication and test of the subscale device to validate the selected concept.

PHASE II: Execute the Program Plan developed in Phase I as directed by the government. Conduct fabrication, integration, testing, and test reporting for the 1/10th scale device as specified in the proposed Program Plan. This test report must discuss fully how key technical challenges were overcome and risks mitigated. Demonstrate clear traceability to a full-scale device and conduct a Preliminary Design for a full scale device. Develop a Phase III Program Plan that will include your integration and test strategy for a full scale device. Identify remaining key technical challenges, risks, and risk mitigation strategies.

PHASE III: Design and build a full scale prototype LRU, demonstrating its ease of handling, storage capability, shipping alternatives and maintenance advantages in a laboratory environment. Perform full scale tests on the prototype to show Iodine production timelines, flow-rate precision and selectability, delivered purity and provide a detailed evaluation report.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient, maintainable, retrievable and safer handling of hazardous chemicals have potential for numerous commercial applications such as avoiding expensive chemical decontamination processes and the reduction of the need for industrial scrubbers. Improved COIL processes also stand to benefit the industrial use of high power lasers for welding, cutting, and other material process applications which require lasers with high power output and excellent beam quality.

REFERENCES: 1. Carroll, D.L., King, D.M., Fockler, L., Stromberg, D., Madden, T.J., Solomon, W.C., and Sentman, L.H., “COIL for Industrial Applications,” AIAA-98-2992, p. 1-11 (1998).

2. Manke II, Gerald C. and Hager, Gordon D., “Advanced COIL – physics, chemistry and uses,” Journal of Modern Optics vol. 49 no. 3/4, p.465-474 (2002).

3. Vetrovec, John, “Prospects for an Industrial Chemical Oxygen-Iodine Laser,” SPIE vol. 2092, p.723-726 (1996).

KEYWORDS: Airborne Laser, Chemical Oxygen Iodine Laser (COIL), Iodine, Iodine Injection